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Discussion of all papers is invited

VOL. 18 NOVEMBER, 1927 No. 5

MACHINES FOR WATER CONSUMERS' ACCOUNTING PROBLEMS[1]

BY D. C. GROBBEL[2]

With the many improvements in methods made in the production and conservation of water, there has likewise been felt among water works executives the necessity of improved accounting methods, especially in that branch of the office work called the "Consumers Accounting." This need is not only felt in privately, but in municipally owned water works. True, privately owned works have been operating, as a general rule, for some years under the public utility commissions and have been conforming with the utility commission uniform system of accounts, and were compelled by law to provide the utility commission with certain accounting information which could be secured only by the use of improved and efficient accounting methods. For this reason, privately owned works were more prompt in studying and setting up improved systems of customer accounting. On the other hand, in the great majority of states, the utility commissions have been prohibited by statute from interfering in the supervision of municipal utilities, and consequently the incentive or compelling power to improve was absent, or at least, was not pressing.

Where no laws prescribed the method of keeping the accounts, the

[1] Presented before the Chicago Convention, June 8, 1927.

[2] Assistant Secretary, Board of Water Commissioners, Detroit, Mich.

incitement to better accounting methods has come from the improvement in the standards of general accounting, or from the fact that the increase in the works' business, on account of the urban growth, made it mandatory that the executive become more thoroughly familiar with other phases, especially the financial, than those applied only to the mechanics of supplying water. A further incentive to the municipal works' executive was to be found in the fact that the executive of the privately owned works had command of a vast amount of detailed knowledge which the municipally owned works' executive did not have, but which he badly wanted. To obtain this knowledge, the executive of the municipally owned works found it necessary, not only to improve his office procedure, but also to make changes in his accounting methods.

The engineer, the supervisor, or the mechanic supplies the data on the physical equipment to the executive. The accountant must perform a like service on the financial conditions and operations. Nor must the accountant be one whit less accurate in his work and statements than the man in charge of the planning, designing or operating of the physical elements of the works. The accountant's work touches all the phases of the works—investments, cost of operation and production, state or municipal regulations and, above all, the accounting relations between the consumer and the works. Certainly, nothing affects the good will of the consumer towards the works as much as accurate methods in keeping these accounts.

The refining of the accounting information needed in the administration of public utilities has been one of constant progress and has called for ever increasing demand for accounting labor. To employ the former type of experienced and reliable accountants at the price such labor commands would manifestly, on account of its cost, be prohibitive if it could be obtained. Information that is desirable, or necessary, has to be obtained and this is impossible with unskilled and cheap labor, unless this labor is given a large amount of assistance that may be called upon to perform certain operations with the least mental effort. This kind of assistance was found in the mechanical equipment.

Having once found that mechanical devices could be used in accounting, the inventive geniuses in the employ of the various office equipment manufacturers began bending their efforts to make these mechanical aids better, more efficient and to a greater extent automatic. For a long time these manufacturers were content to

fabricate their machines for general bookkeeping and to supply the demands of the merchant or manufacturer. Privately owned public utilities, to whom the refinement in accounting information was most needful, sought to make use of these inventions and through their insistent demands, a whole line of equipment, adapted to their uses, has been developed, especially for customer accounting.

The general accounts—balance sheets and other standard financial statements—were similar in their nature to those of other businesses, but some of the subsidiary accounting was vastly different, especially the accounting between the utility, such as water, and the multitude of consumers. These accounts must be absolutely accurate, the statements must be gotten out promptly, must be delivered on a scheduled date and must be intelligible, legible, and above all neat. Privately owned electric, gas and water plants were the first to make use of such consumer accounting methods. Municipal plants were and still are backward in the use of this equipment.

It is not the province of this paper to delve into the underlying causes of this condition, but rather to discuss the use of machines in a water works office in connection with consumer accounting. Detroit was the first of the larger cities to adopt machines for accounting purposes and may now be said to be fully equipped to take care of its accounting, mechanically, in all of its branches, excepting the general books. Billing machines are used for consumer accounting, machines are used for cash postings; abstracting, or checking, is done with machines, addresses are printed on the bills by means of an addressograph, likewise the ledger and route number. By an ingenious device, there is also incorporated in the addressograph an auxiliary printer by which, from time to time, messages from the Department are printed on the bills.

The principal equipment in connection with the keeping of the consumer accounts is the billing machine. Here it may be noted that a ready-made machine does not at all times fit all local conditions, no more than that the same type of pump is suitable for all communities. However, this need not worry the executive who contemplates the installation of such equipment. All manufacturers of this type of office equipment have experts who are conversant with the needs of the water works records in general and who, on request, will make a study of the local needs and be pleased to plan a machine or system for any particular works. Naturally, these manufacturers expect to sell their equipment. At the same time, the manufacturer

does not wish to sell, at the expense of having his system and equipment fail to function properly.

Detroit has been doing real machine billing for the past ten years and the installation of the equipment was the result of the inability to secure competent clerical help at a fair price during the World War. Nor would the Department return to the pre-war status, even should an abundance of cheap labor be procurable, if for no other reason than that the accounts are kept more accurately and the bills are rendered to the consumer in better style and on time, thus making a most favorable impression, and, above all, doing away with numberless complaints on account of inaccuracy and uncertain delivery of bills.

Detroit has today approximately 233,000 active meter accounts, with 1500 flat or assessed rate accounts. The so-called cycle reading of meters is practiced. The readers do nothing but read meters. There is a constant flow of work ready for the billing machines, eight in number. It is expected that shortly, even part of the meter reading work, namely, that of computing the individual consumption, will be done by machine, using some subtracting machines for the purpose of obtaining a total consumption by routes, districts, and areas, to complete the final tie-in with the total consumption, as shown on the billing machines for the same areas.

The billing machines perform the following functions—print date of present reading, the reading, date of previous reading and the previous reading, and the consumption. On the type of machine used, should there be an error in the subtraction, the billing machine automatically locks, preventing a mistake in the billing. Because of the type of rates in force in Detroit, namely, a service charge based on the size of the meter, and a consumption charge, the machine prints the size of the meter and the total amount of the bill. This latter amount is automatically printed on the stub. Provisions are also made to include in the totals, the arrears or miscellaneous charges.

Besides the bill proper, the same operation that prints the bill, prints like information on the abstract sheet, which is used for the purpose of checking and segregating the various kinds of information needed for statistical and control purposes. The machine likewise prints the necessary ledger entries on a card. When the machines were ordered, considerable thought was given to the so-called stub accounting system, as opposed to the ledger card system, which latter system would give a chronological history of the account. The card

system was adopted as being more suitable to conditions existing in Detroit, where the works has a tax lien on the real estate for unpaid water bills.

With the making of the bills, the billing machine carries along both the total of the meter consumption and the amount of money. By breaking down with calculating machines the various consumptions, service charges, arrears, credits and penalties, the correctness of the billing is established. The totals are entered by machine on the control cards. Posting is likewise done by cash posting machines and various segregated totals are received to be posted against the control.

Consumers accounting, by machine, may at first glance appear as something cumbersome to operate and difficult to maintain. However, a short study at close range will soon convince one that every move made is made directly and without any false motions. The information obtained through these movements is the exact information desired. The machines are constructed for that purpose only. Nor is the operation of such a machine difficult, in fact, no more difficult than operating a typewriter or an adding machine, thus allowing the use of boys or girls for this important work.

As stated before, there are a number of types of machines that can be used for customer accounting, some one being suitable for the particular local conditions. Some of the machines are equipped with a regular alphabet, others use only numbers and the symbols or letters necessary to fit the particular system. No office is too large for the use of these machines, nor are there any water works offices so small that a machine, useful for customer billing and other work, cannot be designed.

In conclusion, one water works office, Detroit, is thoroughly sold on machine consumers accounts billing, if for no other reason than that during the last year of the manual billing each employe in the consumers accounting bureau handled 2060 accounts and now each one handles 3650, or an increase, per person, of over 77 per cent. Furthermore, the bills are accurate and neat and the information needed for the general books is readily obtainable and absolutely accurate.

DISCUSSION

C. D. WERNER:[3] The opening paragraph of Mr. Grobbel's paper on "Machines for Water Consumers' Accounting Problems" aptly calls attention to the value and necessity of improved consumers' accounting methods.

In order to appreciate fully the importance of mechanical appliances it should be considered that the solution of these problems has had the attention of mathematicians and inventors for over four thousand years.

The father of the calculating machine was Blaise Pascal, a wonderful French mathematician, who produced the first machine that would carry tens in the year 1641. In 1820 an Englishman by name of C. X. Thomas, built a machine which was called the "Arithmometer." Another Englishman, Charles Babbage, devoted over forty-nine years of his life and more than one hundred thousand dollars in attempting to develop a calculating machine. At the time of his death in 1871, his machine was still unfinished.

It remained for an American, William S. Burroughs, to produce in the year 1888, after eight long years of ceaseless experimentation, the machine which has revolutionized the world's bookkeeping methods.

The application of this machine to consumers' accounting problems marks another milestone along the highway of human progress.

Nothing affects the good will of the consumer as much as accurate methods in keeping records. The public utility billing machine has the advantage of accuracy, speed, durability and economical handling of billing work. Its accuracy and speed are obtained from the automatic features built into the machine, making the work more than 75 per cent automatic. Machine entries on ledger record, bill and cashier's stub are all orginal entries, the figures printed on bill being automatically repeat printed on cashier's stub as well as ledger record. The machine is equipped with a lock to prevent change of figures during this repeat print operation.

We are all thoroughly conversant with the fact that the successful operation of the so-called pen and ink systems depended entirely on the former type of experienced and reliable bookkeepers. Now that this type of office help is no longer available we have turned to the

[3] Public Service Division, Burroughs Adding Machine Company, Detroit, Mich.

mechanical aids to give us the same feeling of satisfaction and security.

Monthly statements to customers must be easily understood, legible and, above all, *neat*. How can we best fulfill these requirements? Only by the use of the public utility machine, because it writes bills that are neat, legible and businesslike in appearance. In addition, it proves the bill for correct writing and charge.

The first information that must be secured is the posting media, the flow of the work, and the information furnished to the customer on the statements. Hence the four most important consumers' accounting records are: (*a*) rate schedule, (*b*) meter read sheet, (*c*) ledger record, (*d*) consumer's bill.

Before attempting to find the correct solution to your problem it it is necessary to study the posting media and decide how to handle the work by machine, as well as the method of proving the work. The posting media, together with the rate structure, will determine the style of machine to use.

Next we must know the number of meters billed each month in order to gauge the volume of work. The type of rates will determine whether we can use billing charts satisfactorily.

From the actual meter read sheets, ledger records and bills, we can obtain the information furnished by the meter reader, method of delivering the bills, method of dating bills to show reading dates as well as discount dates, the space required for the addressograph impression on both bill and stub, also the present method of posting both debit and credit entries to the ledger record.

Next we must make the necessary provision to prove to the general ledger control as well as obtain the essential distribution and statistical information.

In considering the application of machines to consumers' accounting problems, it should be thoroughly understood that, no matter what type of plan is decided upon, the machine operations can be simplified and greater accuracy will be secured by making use of the following desirable features:

a. Automatic cross tabulating carriage. An automatic tabulating motor returned carriage is an important factor in any machine's speedy handling of billing. The machine must automatically tabulate through the various printing positions, stopping at the right place for each entry, then moving on to the next position, all without any attention from the operator. In addition, the machine should

automatically return to first printing position at the completion of each bill.

b. Automatic repeat print. The billing machine repeat prints the items and totals, entered on the bill, as original entries on both ledger and cashier's stub, thereby eliminating the use of carbon records.

c. Automatic writing line finder. This feature causes both bill and ledger to drop into pre-determined writing position without any effort on part of the operator.

d. Automatic opening of throat. This device automatically causes the carriage platen to release the bill and ledger at the completion of each bill for easy removal and insertion of the next consumer's records.

e. Decimal position. Irrespective of the amount set up on the keyboard the machine should automatically select the proper decimal position.

f. Automatic printing of totals. In order to prevent the possibility of copying amounts incorrectly both bill and long totals should be secured by merely depressing total key.

The use of the public utility machines for consumers' accounting work by the City of Detroit Water Department has brought about the following results:

1. Every bill proved before leaving the office.
2. Neatness and legibility of bill improved.
3. Tabulation of income as a by-product of billing.
4. Debit posting a by-product of billing.
5. Ledger record is an exact copy of consumer's bill as rendered.
6. Accounts Receivable ledgers balanced before bills are delivered.
7. Absolute proof of credit posting.
8. Increase of over 77 per cent in the number of accounts handled per employee.

The one common difficulty among all public utility executives, when they are brought face to face with the inadequacy of their present system of handling consumers' accounts, is *lack of time.* The ever increasing pressure of routine duties prevents them from making the careful analysis necessary to solve their own problems. What is the remedy for this condition? Bring in someone whose business it is to plan just such improvements. The manufacturer of this style of office equipment has developed a trained force of experts whose services are now available and who will make the necessary study of your problem and offer recommendations as to the type of mechanical equipment to be used.

REVISED INTERSTATE COMPACT AS TO THE WATERS OF THE DELAWARE RIVER[1]

The Commonwealth of Pennsylvania, the State of New Jersey and the State of New York having appointed as commissioners, for the purpose of negotiating a compact with respect to the water resources of the Delaware river,

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For the Commonwealth of Pennsylvania

WILLARD I. HAMILTON
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EDWARD L. YOUNG
For the State of New Jersey

GEORGE MACDONALD
RUDOLPH REIMER
JEFFERSON DEMONT THOMPSON
For the State of New York

the said commissioners, after negotiations, have agreed upon the following articles:

ARTICLE I

This compact, between the sovereign states of Pennsylvania, New Jersey and New York, is entered into to provide for the preservation of the Delaware river and, consistent with such object, to

[1] Revised recommendations proposed by Commissioners representing the Commonwealth of Pennsylvania, the State of New Jersey and the State of New York, January 13, 1927. The original compact proposed, now revised in the form here given, was printed in THE JOURNAL, February, 1925, p. 160. This revised compact was adopted by the State of New York, but no legislative action was taken in New Jersey and Pennsylvania.

enable each of the said states to make use of a part of the waters thereof for the purpose of meeting present and resonably prospective needs. This compact does not allocate the remaining waters nor fix any ratio or principle to govern future divisions.

Article II

Where used in this compact, singular words shall be considered as including the plural, masculine words shall be construed as including the feminine and neuter, and the following terms and expressions shall have the meanings respectively designated for each:

(1) The term "waters of the Delaware river" means the surface waters originating within the Delaware drainage basin.

(2) The term "channel" or "channel of the Delaware river" means the bed of the Delaware river and the lands on and over which the waters of said river flow, beginning at the place where said river crosses Latitude forty-two degrees (42° 00′), the northern boundary of the Commonwealth of Pennsylvania, and extending thence continuously as the said river winds and turns down to Latitude forty degrees twelve and one-half minutes (40° 12½′) near Trenton Falls.

(3) The term "Delaware drainage basin" means the total area of both land and water from which the surface waters flow down to where the channel of the Delaware river crosses Latitude forty degrees twelve and one-half minutes (40° 12½′).

(4) The term "Upper Basin" means that part of the Delaware drainage basin from which the surface waters flow down to where the channel of the Delaware river crosses Latitude forty-one degrees twenty-one and one-quarter minutes (41° 21¼′), below the mouth of the Neversink river and near the point which marks the boundary between the Commonwealth of Pennsylvania and the states of New Jersey and New York.

(5) The term "Lower Basin" means that part of the Delaware drainage basin which is not embraced within the Upper Basin.

(6) The term "tributary" or "tributary of the Delaware river" means any watercourse, the waters of which naturally flow into the channel of the Delaware river.

(7) The term "development" means making water available for use or diversion by the construction of any intake, dam or other works.

(8) The term "develop" means to make available by development.

(9) The term "point of storage" means the place on a tributary or in the channel of the Delaware river at which a dam is maintained for the purpose of creating storage.

(10) The term "point of diversion" means the place at which water is diverted from a tributary or from the channel of the Delaware river.

(11) The term "diversion" when referring to the water of a tributary means the taking or removal from that tributary of water which is not returned into the channel of the Delaware river either above the point at which the tributary enters said channel or within a distance of twelve miles below that point, measured along the center line of said channel. When referring to the channel of the Delaware river this term means the taking or removal from said channel of water which is not returned into said channel or into the Delaware river below Latitude forty degrees twelve and one-half minutes ($40° 12\frac{1}{2}'$) within a distance of twelve miles below the place of taking or removal, measured along the center line of said channel and river.

(12) The term "divert" means to effect a diversion.

(13) The term "domestic and municipal" as applied to the use of water means the use of water by or for water-works serving the public.

(14) The term "sanitation" as applied to the use of water means the use of water for the conveyance of sewage and other wastes.

(15) The term "industry" as applied to the use of water means the use of water for manufacturing and industrial purposes, other than power, when the water used is not taken from water-works serving the public.

(16) The term "power" as applied to the use of water means all use of water, direct or indirect, for the generation of energy.

(17) The term "navigation" as applied to the use of water means the use of water for transportation and for the operation of water craft.

(18) The term "commission" means the Tri-State Delaware River Commission.

Article III

For the purposes of this compact the order of importance and public value of water shall be: (A) domestic and municipal, (B) sanitation, (C) industry and power, and (D) navigation.

Article IV

Subject to the duties and obligations imposed by this compact, any administrative department or political subdivision authorized in that behalf by or under the laws of any signatory state, or any corporation, partnership, association or person hereafter so authorized, may exercise the rights and privileges herein conferred on such state in conformity with such other terms and conditions as that state may impose and under such further requirements as the commission may prescribe in the exercise of its authority under this compact.

Article V

Subject to the provisions of this compact, each signatory state may divert water from any tributary of the Delaware river within that state or from the channel or from both. The total quantity which may be diverted by each state in any one calendar year shall not exceed the following:

Pennsylvania—Three hundred twenty-eight and one-half ($328\frac{1}{2}$) billion gallons, which total quantity is equivalent to an average of nine hundred (900) million gallons daily.

New Jersey—Two hundred nineteen (219) billion gallons, which total quantity is equivalent to an average of six hundred (600) million gallons daily.

New York—Two hundred nineteen (219) billion gallons, which total quantity is equivalent to an average of six hundred (600) million gallons daily.

The quantities of water herein authorized to be diverted are in addition to all quantities of water which have heretofore been lawfully diverted by the normal operation of all works existing and in actual operation within each state in the Delaware drainage basin when this compact becomes effective, and the future diversion of water in quantities not exceeding those heretofore lawfully diverted by the normal operation of such works shall not be charged against the total quantity which may be diverted under authority of this article by that signatory state in which said works are located.

Article VI

Diversions allowable under Article V may be made by each signatory state from any tributary of the Delaware river within that state for use either within or without the Delaware drainage basin, subject to the following restrictions and limitations:

(1) Authority for every development shall be obtained, and every development shall be carried out, under the laws of the state in which it is located.

(2) On every tributary from which a diversion is made there shall be provided sufficient storage to insure the reserve flows required by this article.

(3) Within the Upper Basin, at all times during the months of July, August, September and October, there shall be released from storage and delivered into the tributary or into the channel of the Delaware river above the point at which the tributary enters said channel, a reserve flow equal to forty-five hundredths (0.45) of a cubic foot per second for each square mile of drainage area above the point of storage; during the remainder of the year such a reserve flow shall be maintained only on the days when the flow from the drainage area above the point of storage is less than forty-five hundredths (0.45) of a cubic foot per second for each square mile of drainage area above the point of storage.

(4) Within the Lower Basin there shall at all times be released from storage and delivered into the tributary or into the channel of the Delaware river above the point at which the tributary enters said channel a reserve flow equal to fifteen hundredths (0.15) of a cubic foot per second for each square mile of drainage area above the point of storage.

Article VII

Diversions allowable under Article V may be made by each signatory state from the channel of the Delaware river for use either within or without the Delaware drainage basin, subject to the following restrictions and limitations:

(1) All diversions shall be made in accordance with schedules which shall be prescribed from time to time by the commission. In the Upper Basin said schedules shall allow to each diverting state at least one-third of the flow over and above the reserve flow requirements; in the Lower Basin said schedules shall allow to each divert-

ing state at least one-half of the flow over and above the reserve flow requirements. Any schedule prescribed by the commission authorizing the diversion of more than one-third of the divertible flow in the Upper Basin or of more than one-half of the divertible flow in the Lower Basin shall not operate to create an irrevocable right to continue such excess diversion nor to prevent the commission from at any time modifying or changing any such schedule to allow to each diverting state in the Upper Basin only one-third of the divertible flow or to allow to each diverting state in the Lower Basin only one-half of the divertible flow, or to prevent the commission from at any time modifying or changing any such schedule in any other manner that may be necessary to meet the conditions existing at the time such change or modification is made.

(2) In the absence of storage at the place where the diversion is accomplished no water shall be diverted from the channel within the Upper Basin unless the flow in the channel is in excess of a reserve flow of forty-five hundredths (0.45) of a cubic foot per second per square mile of drainage area above the point of diversion. In every diversion, in the Upper Basin, made from a storage reservoir lying wholly or in part within the channel, a reserve flow equal to forty-five hundredths (0.45) of a cubic foot per second per square mile of drainage area above the point of storage shall be maintained at the point of storage at all times when the flow in the channel from the drainage area above the point of storage is greater than that amount; when the flow in the channel from the drainage area above the point of storage is less than forty-five hundredths (0.45) of a cubic foot per second per square mile, then a reserve flow equal to the flow from the drainage area above the point of storage shall be maintained in the channel at the point of storage.

(3) In the absence of storage at the place where the diversion is accomplished no water shall be diverted from the channel within the Lower Basin unless the flow in the channel is in excess of a reserve flow of twenty-four hundredths (0.24) of a cubic foot per second per square mile of drainage area above the point of diversion. In every diversion, in the Lower Basin, made from a storage reservoir lying wholly or in part within the channel, a reserve flow equal to twenty-four hundredths (0.24) of a cubic foot per second per square mile of drainage area above the point of storage shall be maintained at the point of storage at all times when the flow in the channel from the drainage area above the point of storage is greater than that amount;

when the flow in the channel from the drainage area above the point of storage is less than twenty-four hundredths (0.24) of a cubic foot per second per square mile, then a reserve flow equal to the flow from the drainage area above the point of storage shall be maintained in the channel at the point of storage.

(4) The reserve flows required under this article at every point of diversion or of storage shall be in addtion to water in transit which may be flowing in the channel at such point.

(5) Every storage reservoir lying wholly or partly within the channel of the Delaware river shall at all times be operated so as not to interfere with or retard the free passage of water in transit, of the required reserve flows and, except as otherwise permitted by the schedules prescribed by the commission, of that part of the flow in the said channel which may not be diverted by the state under the authorization of which state said storage reservoir was constructed.

Article VIII

Each signatory state may authorize an appropriate department to designate as water in transit for the use of that state any or all water that has been or may hereafter be developed by storage for any purpose by or under the authorization of such state either on any tributary within said state or on the channel of the Delaware river. All water so designated shall be known as "water in transit" and may be permitted to flow into and down the channel of the Delaware river. All water which has been so designated shall be considered as having been diverted at the point of storage where it was developed and shall be charged against the total quantity of water which may be diverted by the designating state under the authority of Article V.

Water in transit may be removed from the channel of the Delaware river by or under the authority of the designating state. The daily rate at which water in transit may be removed from the channel shall not exceed the daily rate at which it is delivered and no greater quantity of such water may be removed than shall have been delivered into the said channel. All water in transit shall be subject to the reserve flow requirements of Articles VI and VII which apply at the point of storage where said water was developed. In the case of water in transit from any development completed prior to the date when this compact becomes effective said reserve flow requirements shall, so long as the existing authorization for such development

continues in effect, apply only at times when water in transit from such development is actually flowing in the channel of the Delaware river.

Every designation of water in transit made under the authority of this article shall be evidenced by the filing with the commission of a declaration setting forth the contemplated uses of said water and any such designation may at any time be withdrawn or amended without prejudice to its subsequent amendment or renewal. Notice of every amendment or renewal shall be given to the commission through the filing of a declaration, the provisions of which declaration shall not become effective until two years from the date of the filing thereof unless the commission shall, after hearing, fix an earlier date.

Article IX

With the approval of the commission each signatory state may build dams entirely or partly across the channel of the Delaware river upon such terms and conditions as the commission, after hearing, may prescribe.

All such dams shall be built so as to conform to the requirements relating to physical construction and safety in the state or states in which they are located and shall at all times be operated so as not to interfere with any diversion that is in accordance with schedules prescribed by the commission nor with any water in transit.

Article X

Notice of every development for diversion from any tributary shall be filed with the commission, prior to the beginning of construction, by the state in which the development is located or by the holder of the authorization for such development; said notice shall include a statement of the quantity of water proposed to be diverted, the purpose of such diversion and a copy of the authority for the development.

Article XI

To evidence that the provisions of this compact are being complied with there shall be installed and maintained, in connection with every development which comes under the provisions of this compact,

adequate and suitable equipment for measuring all necessary quantities and rates of water flow. Records of all water flows in connection with such developments shall be kept and furnished to the commission as the said commission may require. Said equipment shall be installed and maintained and said records shall be kept and furnished by the state or by the holder of the authorization for every such development.

Article XII

No water from the Delaware drainage basin shall be diverted for use outside the boundaries of the states signatory to this compact. Except by legislative act no signatory state may give, grant or dispose of to another signatory state, or to the holder of an authorization therefrom, any water allotted to it or developed by it under the provisions of this compact. The joint exercise by or under the authority of two or more of the signatory states of any right under this compact is hereby authorized.

Article XIII

The signatory states, recognizing the importance of conserving the sanitary quality of the waters flowing in the channel of the Delaware river so that these waters may be used as sources of domestic and municipal water supplies, agree to co-operate in carrying out a policy for maintaining said waters in a sanitary condition at least equal to that which obtains as of the date when this compact becomes effective.

Article XIV

The beneficial effects of forest covered areas on the regularization of stream flow, with attendant greater potential use of streams for domestic, industrial, navigation and other purposes, are recognized by the signatory states. Each signatory state agrees to adhere to a policy covering the establishment and maintenance of an adequate forest cover in the Delaware drainage basin and the maintenance of the highest practicable standards of protection from fire on these lands.

Article XV

Each signatory state, in the exercise of any right under this compact, may take and condemn any property necessary for the construction, maintenance and operation of any dam in or across the channel of the Delaware river. Each signatory state may also take and condemn any rights to the use of or in water, the taking or condemnation of which rights is necessary to effect any allowable diversion made under this compact from any tributary or from the channel of the Delaware river. The power of condemnation herein conferred shall be exercised in accordance with the laws of the state in which the property or the rights to be taken or condemned are located. Any such property and rights, though devoted to a public use, may be taken and condemned in favor of any public use higher in the order of importance set forth in Article III.

Article XVI

All damage to persons or property resulting from the exercise of any rights under this compact shall be determined under the rule of damages, in accordance with the procedure, and in such manner as is provided by the law of the state in which the damages are suffered. The damages suffered in the State of Pennsylvania shall be ascertained, recovered and paid as provided by the forty-first section of the act approved April twenty-ninth, one thousand eight hundred and seventy-four (Pamphlet Laws 73) and the amendments and supplements thereto or any substitute therefor in effect when the development is authorized. The damages suffered in the State of New York or in the State of New Jersey shall be ascertained, recovered and paid as provided by any general or other now existing act applying thereto or any substitute for the same in effect when the development is authorized. The court or courts which have jurisdiction of the subject matter in the respective states shall have jurisdiction of the person of every party in interest for the purpose of notice, summons and hearing throughout all three signatory states.

Article XVII

Any property of a signatory state or of the holder of an authorization of such state, acquired in the exercise of any right or privilege under this compact, which is located in any other signatory state

shall be subject to taxation as private property under the general laws of the state in which it is located.

Article XVIII

Nothing in any existing treaty or compact between any two of the signatory states shall be modified or changed or invalidated by anything herein contained except in so far as the same is repugnant to any provision of this compact.

Article XIX

The Tri-State Delaware River Commission is hereby created as a body corporate to consist of not more than three members from each of the signatory states. Each state may, by appropriate legislation, provide for the designation, appointment and tenure of its members. Until such time as a signatory state shall by legislation otherwise provide, the Governor of such state is hereby directed to designate an appropriate officer or employee and may appoint not more than two other persons to represent said state as members of the Tri-State Delaware River Commission.

Each signatory state shall have one vote in the commission. Every decision, authorization or approval of the commission shall require a unanimous vote of the states entitled to vote thereon. On matters pertaining only to the Lower Basin, the State of New York shall have no vote.

Every decision, authorization or approval rendered shall be accompanied by a certificate of the commissioners that the same is, in their judgment, in the public interest and such certificate shall state the reasons on which the decision, authorization or approval is based.

The powers and duties of the commission, in addition to those hereinbefore set forth, shall be:

(1) To make rules and regulations for the organization and the conduct of its business.

(2) To report annually to the governors for the information of the legislatures of the signatory states as to the developments under the terms of this compact and as to such other matters as may come within the purview of the commission.

(3) To report in like manner at intervals of not more than five years as to the existing and reasonably prospective needs of the

signatory states and the extent to which and the manner in which each signatory state has exercised its rights under this compact.

(4) To observe the operation of all developments; to make such orders in writing after hearing as may be necessary to secure compliance with those provisions of this compact which are within the jurisdiction of the commission; and to institute any appropriate action or proceeding at law or in equity to enforce compliance with such orders and with the terms and conditions imposed in any decision, authorization or approval made by it.

(5) To require by order in writing compliance with Article XI.

(6) To make, modify and change the schedules referred to in Article VII.

(7) To make such examinations as may be necessary to ascertain the quantities of water heretofore lawfully diverted by the normal operation of all works existing and in actual operation when this compact becomes effective.

(8) The commission or any member thereof or any employee or other person duly authorized thereby is hereby empowered to enter without let or hindrance upon the lands and property upon which any development is being constructed, operated or maintained under this compact. Each state through its appropriate departments shall coöperate with the commission in obtaining such data, information and records as may be necessary in the performance of its duties.

(9) Whenever, by this compact, provision is made for action by the commission after hearing, notice of such hearing shall be given to the governor of each state at least ten (10) days before the date set for such hearing.

(10) The attorney general of each signatory state or a deputy or assistant shall serve as the legal adviser of the commissioners representing that state.

(11) The commission is authorized to provide suitable offices and conveniences for the transaction of its business and to employ such technical and clerical assistance as may be necessary to enable it to carry out the duties imposed by this compact. The expenses of the commission shall be paid, share and share alike, from funds provided by each of the signatory states in such manner as the laws of the signatory states shall prescribe.

ARTICLE XX

Notwithstanding anything contained in this compact, each state may institute any action or proceeding at law or in equity for the enforcement or protection of its rights or the rights of its citizens accruing under this compact or otherwise.

ARTICLE XXI

The governors of the signatory states—upon the request of any one of them, shall each forthwith appoint a commissioner, and the said commissioners are empowered to consider and recommend modifications of this compact and upon adoption by the legislative act of each and all of said states, the Congress of the United States having consented thereto, such modifications shall be in full force and effect.

ARTICLE XXII

Should any part of this compact be held to the contrary to the constitution of any signatory state or of the United States all other severable parts of this compact shall continue to be in full force and effect.

ARTICLE XXIII

The consent of the Congress of the United States to this compact shall in no wise affect any existing Federal statute.

ARTICLE XXIV

This compact may be terminated at any time by concurrent legislative action of all the signatory states. In the event of the termination of this compact all rights which may have become vested under its provisions shall remain and continue unimpaired.

ARTICLE XXV

This compact shall be submitted for adoption to the legislature of each of the signatory states at the several sessions beginning in the month of January, nineteen hundred and twenty-seven; and upon adoption by the legislative act of each and all of said states the Congress of the United States having consented thereto, it shall be in full force and effect.

IN WITNESS WHEREOF, the commissioners have signed this compact in triplicate originals, one of which shall be deposited with the Secretary of State of each of the signatory states.

DONE at The City of New York, New York, this thirteenth day of January, in the year of our Lord, one thousand nine hundred and twenty-seven.

CHARLES H. MINER
ROBERT Y. STUART
PHILIP P. WELLS
WILLARD I. HAMILTON
HENRY G. PARKER
HARRY BACHARACH
S. WOOD MCCLAVE, JR.
CARROLL P. BASSETT
F. MORSE ARCHER
GEORGE MACDONALD
RUDOLPH REIMER
J. D. THOMPSON

NEW YORK CITY'S FUTURE PROPOSED WATER SUPPLY FROM THE DELAWARE RIVER[1]

Under date of October 9, 1926, the Board of Water Supply recommended the approval of a plan for securing an additional supply of water from Dutchess, Columbia and Rensselaer counties. This plan recommended the best of those sources of supply which at that time appeared to be available and eliminated reference to the waters of the Delaware river, which were then the subject of discussions between Commissions representing the states of New Jersey, Pennsylvania and New York. These commissions completed their labors on January 13, 1927, and unanimously agreed upon a form of compact[2] providing for an apportionment of the waters therein referred to, which came before the legislatures of the three states at their respective sessions, recently concluded.

This form of compact was adopted by the legislature of New York and duly signed by the Governor. In New Jersey and Pennsylvania no legislative action was taken. In Pennsylvania the power and authority of the compact commission terminated with the submission of its report and there is now no body formally authorized to represent that state. The legislature of Pennsylvania does not again meet in regular session until January, 1929. It is evident, therefore, that no determination under said compact relating to the waters of the Delaware river can be had for a number of years to come.

The urgency of proceeding in this matter of securing an additional supply of water is compelling. Further delay is fraught with risk. Four years have already elapsed since the first steps looking toward a formal compact with respect to the waters of the Delaware river were taken. During this period two forms of compact were negotiated but the legislation necessary to the confirmation of either was not had. The city should not wait longer. In every sense the best supply for meeting the vital needs of the city is to be found in these

[1] Editorial abstract of Report of Board of Water Supply of New York City to Board of Estimate and Apportionment, July 27, 1927.

[2] Reprinted in full on page 417, This Journal.

waters which have their origin in the state of New York and which are tributary to the Delaware river.

The Board of Water Supply therefore recommended that the Board of Estimate and Apportionment return, without approval, the plan submitted under date of October 9, 1926, and, as a substitute therefor, approve of the following plan, which looks toward the development and utilization of 600 million gallons daily of the flood waters of the following tributaries of the Delaware river: East Branch, Neversink, Little Delaware, Beaver Kill, Willowemoc.

This plan also includes the waters of Rondout creek, a tributary of the Hudson river.

The flood waters of the Delaware will be stored in reservoirs provided for that purpose and conveyed into a reservoir in the Rondout valley, from which place a tunnel deep in the rock and 49 miles long will carry them into the present West Branch reservoir, on the Croton watershed. Another tunnel will extend from the West Branch reservoir to Kensico reservoir and thence to Hill View reservoir, where connection will be made with both the present Catskill delivery tunnel and the new delivery tunnel authorized by the Board of Estimate and Apportionment on March 10, 1927.

Details of the above plan are shown on figure 1, dated June 21, 1927.

The plan proposed for the taking of the flood waters of the Delaware is predicated directly on the form of compact agreed to by the commissioners of the three states on January 13, 1927, which form of compact, moreover, has been sanctioned through its adoption by the legislature of New York and subsequent signature of the Governor. The reservoirs to be constructed under the proposed plan will be operated in such manner as to withhold water from the tributaries on which they are located only when the flow therein is greater than the ordinary flow; at all other times the ordinary flow will be maintained. Moreover, during July, August, September and October, irrespective of the flow in the tributary, water may be released from these reservoirs in such manner that the ordinary flow will be continuously maintained. The effect of so operating the storage reservoirs will, on the one hand, be to diminish the flood flows in the Delaware while on the other the low season flows will be augmented and increased. The increase in the low season flows will thus be in proportion to the dryness of the season,—that is to say, the drier the year, the greater will be the proportionate increase in flow in the Delaware river.

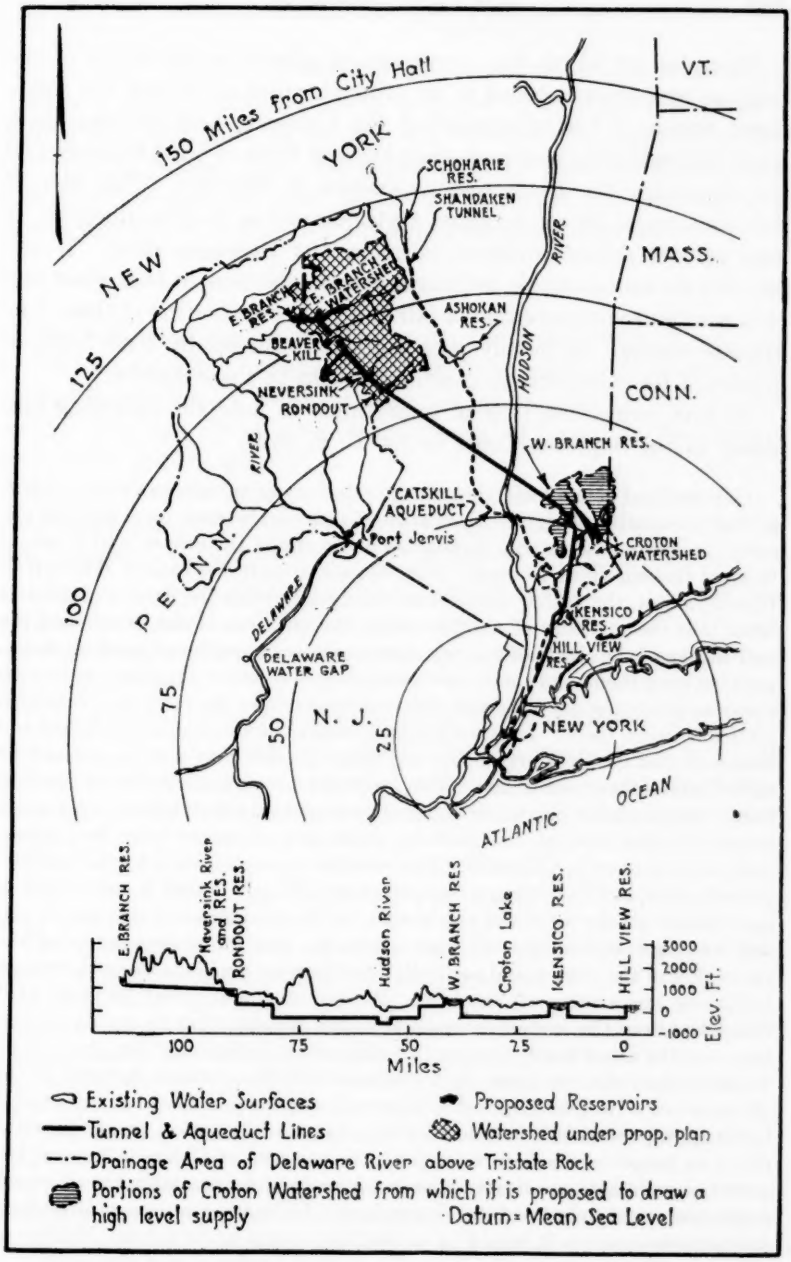

FIG. 1. PLAN AND PROFILE OF NEW WATER SUPPLY PROJECT FOR NEW YORK CITY

The plan on which the above stated scheme of operation of the storage reservoirs is based is, in principle, that of storing the waste flood waters of the tributaries of the Delaware and utilizing them both for regulating and increasing the low flows of the Delaware and for supplying the needs and necessities of the city. This plan is fair and equitable to the other states as well as to all municipalities and private persons everywhere along the Delaware river. It will involve no unreasonable interference with the flow in that river and will constitute no more than a fair and just conservation of these now useless waters. It merely represents the exercise by New York of a part of its reasonable and ultimate right in these waters.

In this connection it is of importance to note the following language of the Supreme Court in 206 U. S. 46:

> One cardinal rule, underlying all the relations of the states to each other, is that of equality of right. Each state stands on the same level with all the rest. It can impose its own legislation on no one of the others, and is bound to yield its own views to none. Yet, whenever, as in the case of Missouri v. Illinois, supra, the action of one state reaches, through the agency of natural laws, into the territory of another state, the question of the extent and the limitations of the rights of the two states becomes a matter of justiciable dispute between them, and this court is called upon to settle that dispute in such a way as will recognize the equal rights of both and at the same time establish justice between them. In other words, through these successive disputes and decisions this court is practically building up what may not improperly be called interstate common law. This very case presents a significant illustration. Before either Kansas or Colorado was settled the Arkansas river was a stream running through the territory which now composes these two states. Arid lands abound in Colorado. Reclamation is possible only by the application of water, and the extreme contention of Colorado is that it has a right to appropriate all the waters of this stream for the purposes of irrigating its soil and making more valuable its own territory. But the appropriation of the entire flow of the river would naturally tend to make the lands along the stream in Kansas less arable. It would be taking from the adjacent territory that which had been the customary natural means of preserving its arable character. On the other hand, the possible contention of Kansas, that the flowing water in the Arkansas must, in accordance with the extreme doctrine of the common law of England, be left to flow as it was wont to flow, no portion of it being appropriated in Colorado for the purposes of irrigation, would have the effect to perpetuate a desert condition in portions of Colorado beyond the power of reclamation. Surely here is a dispute of a justiciable nature which might and ought to be tried and determined. If the two states were absolutely independent nations it would be settled by treaty or by force. Neither of these ways being practicable, it must be settled by decision of this court.

New York, in now proceeding to utilize a small portion of the flood waters of these tributaries which originate, and for the use contemplated always remain, on her soil, will merely be moving toward the assertion of a basic and inalienable right in equity. There is no precedent denying the right that is sought to be exercised; there is no statute which forbids it either expressly or by implication.

THE COST OF THE PLAN

The estimated cost of all the constructions necessary to provide a new and additional supply of 510 to 540 million gallons daily delivered into Hill View reservoir, together with similar delivery of 100 million gallons daily of water from the higher levels of the Croton watershed, is $272,587,000.

This cost will be spread over a period of about twelve years.

In the report of the Board of Water Supply of October 9, 1926, it was pointed out that any deficit which may at any time exist can be reduced or entirely eliminated by a suitable revision of the existing water rate schedules. And it should here be remarked that there has been no increase in the water rates since the present schedule was adopted, in 1857.

In connection with the consideration of the financial aspects of this plan, it is to be pointed out that as the expenditures involved in the recommendations presented are for water supply purposes, they will not operate to reduce or impair the debt incurring capacity of the city.

REASONS FOR THE PLAN

The plan herein presented, aside from the considerations already stated, is further based on the following reasons:

1. It is the most economical and will insure a supply of not less than 500 million gallons daily of new and additional water at a saving in cost of more than $75,000,000 over the plan of October 9, 1926, which looked toward obtaining 434 million gallons at an estimated cost of $347,934,000.

2. The water proposed to be secured is pure and wholesome and of excellent quality.

3. The development of this plan will involve a shorter length of aqueduct, fewer reservoirs, the acquisition of a minimum of real estate, the interference with fewer communities and the relocation of a smaller mileage of highways and railroads than under the plan previously submitted.

4. The water which it is proposed to take is the flood water of the tributaries which rise within the sovereignty of the state of New York. These waters,

before they reach the channel of the Delaware river, are wholly and completely within the possession and jurisdiction of the state of New York. The very least right which New York has in them is equal to the right of New Jersey and to that of Pennsylvania. No one of the states should, under any rule of reason or equity, either claim or take all of this water. Neither should any one of them deny to either or both the others the right to use a reasonable share thereof.

5. The plan proposed will cause neither injury nor damage to any person or property along the Delaware river. The flood flows will be reduced and the low season flows augmented. This proposal of increasing the low season flow is, under the circumstances, purely voluntary, but, in their judgment, it accords exactly with the fair and equitable principles which were agreed upon in the forms of compact negotiated and signed by the commissioners of the three states on January 24, 1925, and January 13, 1927.

6. Similarly, the plan proposed does not, in the total quantity of water to be taken, go beyond the *minimum* limit agreed upon in the form of compact dated January 13, 1927.

7. New York has physical possession of the waters which this plan proposes to utilize. These waters now flow unused to the ocean. They benefit no one, and in times of flood are ever a potential source of danger. New York, in possession of these waters, may well use them for the purpose of supplying the needs of her greatest city. Should either or both of the other states feel aggrieved or believe that they will be damaged by the carrying out of the plan as proposed, their only remedy will lie in an action brought in the Supreme Court of the United States. This Court, in many similar cases, sitting as an arbitrator and construing the principles of both justice and equity, has established so firm a line of precedent that, so far as the plan proposed is concerned, New York can have no fear as to the outcome.

8. The Supreme Court of the United States has clearly intimated that, with respect to any interstate matter and before the Court should take cognizance thereof, ". . . . the case should be of serious magnitude, clearly and fully proved and the principle to be applied should be one which the Court is prepared deliberately to maintain against all considerations on the other side . . . ." (Missouri v. Illinois 200 U. S. 496).

Under the plan proposed, neither New Jersey nor Pennsylvania will be able to prove that the taking of these flood waters is either of serious magnitude or that any damage will accrue by reason thereof. New York should be prepared to admit that each of the three states has the right to use a portion of the water of the Delaware river. And when it is noted that the waters which are proposed to be taken are only a part of the share to which New York is reasonably entitled, it would seem that no action which either of the other states can bring could stop New York from using that herein sought.

9. It may be said by some that New York should not, in so important a matter as her water supply, embark on an enterprise which involves the exercise of rights as to which doubts may be raised. The answer to this contention naturally is that the proposed exercise of these rights does not go beyond a conservative and reasonable point; that the rights of New York are not inferior to those of the other states; that New York is constrained to insist on

them as both fair and evident; that the only tribunal empowered to determine the questions involved, if they be ever raised, is the United States Supreme Court; and that to this court New York, if need be, is ready and willing to submit her case, not alone because of her own needs and public requirements, but also because of the great importance which the utilization of interstate waters is certain to have on the development and growth of our country as a nation. Finally, and of great moment in any consideration of this question, is the fact that the plan proposed for developing these flood waters seeks to apply them to domestic and municipal use, which is the highest and most important use known.

The recommendations are predicated on the reasons which have been presented. The urgent need of proceeding on a program for a new supply of water was set forth in the report of October 9, 1926. The present supplies of water will serve to meet the requirements of the city until 1935. Only eight years remain in which to carry through the great works which must be completed before new water can be delivered. The importance and urgency of the situation is thus emphasized.

The following specific recommendations were, therefore, presented:

First: That the Board of Estimate and Apportionment return, without approval, to the Board of Water Supply, the map and plan dated September 13, 1926, which was transmitted with the report dated October 9, 1926.

Second: That the Board of Estimate and Apportionment, under the provisions of Section 3 of Chapter 724 of the Laws of 1905, as amended, approve and adopt the map and plan dated June 21, 1927.

Third: That, upon the approval of the plan, the Mayor, on behalf of The City of New York, make application, under the provisions of Section 522 of the Conservation Law, by petition, in writing, to the Water Power and Control Commission, for the approval of the said map, plan and profile of the proposed new sources of water supply.

Fourth: That steps be taken to secure suitable amendment of Chapter 724 of the Laws of 1905, so as to render the provisions thereof in all respects applicable to the contemplated operations in Delaware, Sullivan and Ulster counties.

Fifth: That, upon the approval of the map and plan dated June 21, 1927, and upon the making of petition to the Water Power and Control Commission, the Mayor, for and in the name of, the City of New York, do, in writing, advise the Governors of the states of New Jersey and Pennsylvania of the said approval and of the petition then being presented to the Water Power and Control Commission of the State of New York.

RECONSTRUCTION OF INADEQUATE WATER DISTRIBUTION SYSTEMS[1]

By Charles E. DeLeuw[2]

During recent years the writer has had occasion to report on the water works in a number of municipalities where existing water distribution systems were inadequate for the needs of the community. In a number of cities the distribution system was designed and constructed a generation or more ago. The original design may have been adequate for the needs of the municipality at the time of construction, but, judging from the existing conditions in several instances, it is obvious that no provision was made for growth either in population or area.

For various reasons the standards achieved in the early design of many water distribution systems fall short of present day requirements. The density of population and the concentration of urban development in our cities undoubtedly was less than at present. The capacity of old water mains has been greatly reduced in many instances by encrustation.

It is frequently found that the original gridiron was properly designed. However, additions to the original system have been constructed from time to time with but little, if any, thought given to the effect upon the distribution system as a whole. The result is a deficiency in cross connections and a surplus of dead ends. These factors, or some of them, have been the cause of partial break down of distribution systems in a number of Illinois municipalities. In two places the distribution system was found to be not only entirely inadequate for fire protection, but also for domestic requirements.

PRESENT DAY REQUIREMENTS

The National Board of Fire Underwriters has performed a very useful service in clearly setting down the fire protection requirements of the several parts of the water works system. The standards

[1] Presented before the Illinois Section meeting, January 28, 1927.

[2] Of Kelker, De Leuw and Company, Consulting Engineers, Chicago, Ill.

which have been established by it and which are generally accepted by water works engineers are particularly clear with respect to the water distribution system. These standards, established after years of thought and experience, show a gradual revision upwards, particularly as regards capacity of the distribution system and number of fire streams to be concentrated in given areas. For this reason, a distribution system which has been in place for twenty years or more seldom meets all of the requirements of the Board of Underwriters.

DESIGN

The municipality which has outgrown its distribution system is faced with heavy expenditures, if the entire system is to be rebuilt. Other underground and surface structures are in place and the cost of the work is increased by the necessity for cutting the existing pavements, sidewalks and other structures and their replacement. Such work is usually located in a built-up urban area, requires the use of hand labor almost exclusively and therefore introduces an added element of cost. There is an inconvenience factor also in the tearing up of streets, which, while not reflected in the cost of the work, does affect the convenience of the people residing in the community. This factor may assume large proportions in the eyes of the average citizen. The designer, therefore, must prepare a plan which will involve the least cost and inconvenience. A complete design of a new distribution system should always be made. As a matter of policy, however, the first construction may be limited to the arterial water mains branching out from the pumping plant and connecting and articulating the existing gridiron. If the existing system is deficient in cross connections or if it has a large number of dead ends, opportunity can be taken to remedy such deficiencies coincident with the installation of arterial mains.

At the intersection of arterial mains with existing mains, gate valves should be installed of such diameter as will conform to the size of the main to be installed in the complete new system. Where the existing main is of smaller diameter than that shown in the final design, reducers can be used pending the installation of the new main. This permits the smaller mains in the gridiron to be replaced at some subsequent date with a minimum of inconvenience and cost.

FINANCING IN THE STATE OF ILLINOIS

The large cost of a system of arterial water mains generally gives rise to a financial problem of serious proportions. There are in general three means available for financing municipal water works improvements in the State of Illinois. They are as follows:

a. Use of the waterworks fund or general funds of the municipality, including the use of general obligation bonds of the community. This is an excellent way of financing any municipal improvement, but ordinarily it is out of the question because the average Illinois municipality has bonds outstanding almost up to its authorized bonding limit. Moreover, in many cases, the entire bonding limit of the city would be insufficient to finance an arterial water main improvement.

b. Water certificates can be used for constructing waterworks and appurtenances. This class of security is fairly well known to most water works engineers. It is a certificate which is a lien on the plant (paid for out of the proceeds of the sale of water certificates) and on the earnings of such plant. The municipality stipulates in the agreement under which the certificate is issued that rates will be maintained so as to insure net revenue sufficient to provide for the interest and sinking fund requirements of the issue. Where an entirely new plant is being built it is possible that water certificates could be utilized both for the water supply pumping plant and water distribution system. However, it is the opinion of competent lawyers that water certificates cannot be issued to pay for the cost of a system of arterial water mains when constructed as a separate improvement.

c. The most practical way of financing water main construction is by special assessment under the Local Improvement Act. This procedure has been adopted in the three municipalities described below. One technical legal difficulty, however, which must be avoided is that of making the improvement a general improvement. Under existing statutes an improvement, to be a local improvement, must be one where various parcels of land in the municipality will receive an extra or special benefit over and above the general benefit received by the community as a whole. In order to avoid this legal technicality it is well either to omit a small portion of the municipality from the improvement district or to divide the municipality into two or more water districts.

Recently the writer has prepared plans for improvement of the existing systems in three Illinois municipalities: Riverside, Taylorville and Libertyville.

RIVERSIDE

Riverside is a village of approximately 5000 population, located ten miles west of the central business district of Chicago. It is a residential community and its outstanding characteristic is the novel

curving street lay out made by Frederick Law Olmstead at the time the village was developed, shortly after the Civil War. It is understood that the original distribution system consisted of wood pipe and that this was gradually replaced with cast iron pipe, so that in 1923 the major portion of the village was covered with a gridiron of cast iron pipe, primarily of 4 inches in size.

The water supply of Riverside is from wells about 2,000 feet in depth penetrating Potsdam sandstone. The mineral content of the water is high. Deposits up to 1 inch in thickness have been found in the old mains, thus cutting the effective diameter of 4-inch mains to $2\frac{1}{2}$ inches, or in extreme cases to 2 inches. As a result of this there was almost no fire protection in the village, except in the immediate vicinity of the pumping plant. At peak hours of consumption the capacity of the distribution system was such that it was impossible to get water above the basement in many parts of the village. Such a situation was intolerable and brought forth an urgent demand that the situation be remedied.

The unique street lay out of Riverside lends itself readily to the construction of arterial water mains, so that such arterial mains were constructed varying from 8 to 16 inches in size, with additional 8-inch mains eventually to be constructed in those streets destined to become business streets at some future time.

In the levying of the assessment for the construction of arterial water mains it was assumed that all of the existing 4-inch water mains would be replaced eventually by 6-inch mains. It was reasoned, therefore, that property abutting on the streets where new arterial mains were to be constructed would receive an additional benefit over and above the general benefit to the other lands in the water district approximately equal to the cost of a 6-inch main. The policy of disconnecting existing services to houses from existing small mains and connecting to the new large mains was adopted. In order to make the improvement complete, it was also determined that new services should be installed, connected to the new mains, for all of the lots abutting on the improvement, so as to remove the necessity for again destroying the pavement at any future date. In spreading the assessment, therefore, the commissioner first computed the cost of the water services, charged them directly against the property served, then computed the cost of 6-inch mains in front of the various parcels of property abutting on the streets improved and deducted the total which could be spread in that manner from the total cost

of the improvement. The balance was spread against the entire water district. The cost of the improvement to a lot fronting directly on the new water main averaged about $2.30 per front foot of property and the cost of the improvement to the lots indirectly benefited amounted to approximately 30 cents per front foot of property.

The improvement was constructed in the year 1925 and resulted in immediate relief of the situation. Since that time no difficulty has been experienced with domestic pressure, and except for certain dead areas somewhat remote from the new arterial mains, the fire protection afforded by the new system is adequate. It seems likely, therefore, that the time for replacing the existing 4-inch mains will be indefinitely delayed.

TAYLORVILLE

The situation in Taylorville in 1926 was somewhat similar to that described in Riverside. Taylorville is a city of approximately 8000, the county seat of Christian County, and has a rectangular street lay out. Taylorville has its water supply in shallow wells and the water has a rather high mineral content. The use of this water has caused incrustation, but not to the same extent as at Riverside. The capacity of the existing water distribution system at Taylorville, however, is far below that required to give even reasonably good service. Some 98 per cent of the existing water main is but 4 inches in internal diameter and almost 50 per cent of this is on dead ends. For this reason the situation is almost as acute as that existing in Riverside in 1923.

The working pressure at the pumping plant is maintained at about 80 pounds per square inch and notwithstanding this pressure the effective pressure at houses during peak hours of the summer months is far from satisfactory. This is clearly evidenced by tests made in June, 1926. Tests were made of pressures at various hydrants with the hydrant closed and with no nearby hydrant open. Subsequent tests were made with the nearest hydrant open. The results set forth in table 1 indicate clearly the inadequacy of the existing 4-inch grid to provide the necessary flow.

Taylorville represents an average central Illinois community which is the center of a large farming area and which also has a moderate industrial development. It is a city which has had a consistent growth and which will no doubt enjoy a healthy growth in the

TABLE 1

Taylorville Water Distribution System—summary of pressure tests—June 23, 1926. Average pressure at pumping station, 78 pounds per square inch

Pressure at hydrant "A"—normal water demand

	LOCATION OF HYDRANT "A"	TIME	POUNDS PER SQUARE INCH
1	N. E. Corner of Square	10:45	46
2	N. W. Corner of Square	10:50	47
3	S. W. Corner of Square	11:08	47
4	S. E. Corner of Square	11:20	48
5	Elm and Snodgrass	11:35	52
6	Elm and Cherokee	11:48	55
7	Poplar and PawPaw	1:12	60
8	Poplar and Cheyenne	1:24	57
9	Poplar and Washington	1:45	45
10	Poplar and Cheney	1:53	45
11	Poplar and Mortan	1:58	46
12	Adams and Cheney	2:06	48
13	Market and Harrison	2:13	45
14	Adams and Washington	2:28	37
15	Cherokee and Franklin	2:34	63
16	Adams and East End	2:45	56
17	Wyandotte and Palmer	2:50	46
18	First and Shumway	3:12	47
19	Rich and Cheney	3:22	46
20	Market and Walnut	3:33	72
21	Palmer and Washington	3:00	46

Pressure at hydrant "A"—hydrant "B" open

LINE	LOCATION OF HYDRANT "B"	POUNDS PER SQUARE INCH
1	City Hall	15
2	N. E. Corner of Square	16
3	Alley one-half Block South	12
4	Alley one-half Block South	17
5	Elm and Long	6
6	Cherokee and Esther	8
7	Poplar and Chestnut	6
8	Poplar and Utah	21
9	Poplar and Clay	15
10	Poplar and Morton	15

TABLE 1—*Continued*

LINE	LOCATION OF HYDRANT "B"	POUNDS PER SQUARE INCH
11	Poplar and Cheney	12
12	Adams and Powers	5
13	Market and Morton	7
14	Adams and Madison	17
15	Adams and Wyandotte	43
16	Adams and Moore	4
17	Wyandotte and First	16
18	Rich and Morton	8
19	Rich and Houston	8
20	Market and Pawnee	44
21	600 feet North of Palmer	6

future. On the other hand, it is not developing at such a pace as will permit the construction of large mains in new subdivisions in outlying territory which would relieve the situation.

Arterial water mains have been planned for relief and it is proposed to construct these mains by special assessment and in two improvements. Taylorville is somewhat unique in that there is considerable built-up urban area which must be taken into account in any design, but which cannot be assessed due to the fact that it is outside the municipal boundaries. It would seem somewhat unfair to assess property within the existing city limits for an improvement which must be designed to provide for territory now outside the city. However, this seeming unfairness can be eliminated at the time that these subdivisions come into the city or when the property within them makes a connection to city water. At that time a charge can be made for the connection which will serve to equalize the burden on all of the property served.

After the construction of the proposed arterial mains, with the existing 4-inch mains, there will be a fairly satisfactory grid, which should be reasonably adequate for some time. While it is certain that the existing 4-inch mains will be replaced at some date in the future, it is thought that such construction will likely be postponed so long that it would be unfair to take that into consideration in connection with the assessing of the cost of this improvement. It has been determined, therefore, that the cost of the improvement shall be borne equally by all of the lots and parcels of land in the water

district, except in the case where a new arterial main will be constructed in a street where there is no water main at the present time, in which event the property will be charged an amount over and above the general assessment equal to the cost of a 6-inch water main.

For various reasons it was decided not to alter the service pipes in connection with the arterial water main construction and for that reason all of the existing 4-inch water main pipes will be kept in service. This has necessitated a number of rather awkward and perhaps unnecessary connections. It will be the policy of the city, however, to require connections to be made to the new mains at some time in the near future, at which time the 4-inch mains paralleling the new arterial mains can be put out of service.

LIBERTYVILLE

Libertyville is a village of about 3000 population, located near the center of Lake County. Libertyville is a rapidly growing residential surburban community somewhat like Riverside, but unlike Riverside it is a community which is expanding in area as well as in population. Libertyville has had a very rapid and vigorous growth in the last few years and is fairly typical of the suburban communities in the Chicago district, many new subdivisions having been made on the outskirts of the older and closely built-up portion of the village.

The water supply of Libertyville is from shallow wells and the quality of water is such that no serious incrustation has taken place. The gridiron of mains existing in 1925 consisted largely of 6-inch mains adequate to supply the population of a small village of one or two thousand which was the population at the time the majority of the mains were constructed. About two years ago some 1,600 acres of adjacent territory were annexed to the village and in the last two years it has been built up rapidly. This has permitted the development of portions of an arterial water main system in connection with construction of water mains for new subdivisions. It is expected that in this way a distribution system will be completed ultimately adequate to supply the needs of the enlarged community.

A small amount of 10- and 12-inch diameter water mains has been constructed in the southerly part of the village in accordance with a general plan for future arterial mains. The work has been financed by special assessment and ordinarily the water district included within any given improvement has been rather small. The subdivision being served by any particular improvement has been obliged to

assume its share of the cost of the arterial mains and any cost over and above that cost, which could not be fairly charged to the water district, has been assessed as public benefit. This system of financing which has been established in Libertyville is perhaps as painless and satisfactory as any which could be devised. It will, however, require several years for final completion.

DISCUSSION

G. C. HABERMEYER: Chemical reactions of water from two wells probably cause the deposits which are found in pumps, meters and mains.

H. RINGNESS: Where a main is laid in a street in which there is an old main, why not leave both mains in?

CHAS. E. DE LEUW: They were left in place in Riverside, although leakage would be reduced if old mains were abandoned. Service connections with the new mains give much better pressures than if made with the old mains.

J. J. WOLTMANN: Where assessments are made and payments are to be made by districts to be served later, how can funds be collected from such districts and paid back to property owners who have paid for the improvements?

CHAS. E. DE LEUW: Theoretically, a city can exact payment from a territory to be connected and could pay the money into special assessment funds, but actually it is not likely to be done.

THE NEW FILTER PLANT AT FORT COLLINS, COLORADO[1]

By Wynkoop Kiersted[2]

A description of the old plant of the Fort Collins water supply works will not, in all probability, be a matter of interest further than the general statement that it consisted of a series of negative head mechanical filters with a clear water basin beneath them, an adjoining coagulating basin, a small basin in which coagulants are applied, and a basin of a capacity of about two million gallons, primarily designed for storage purposes to tide over intervals of high river turbidity. The water from both the old and the new plant flows by gravity to distant distributing reservoirs, thence into the distributing system of the city under sufficient pressure for general service. The new water purification plant adjoins the old one and is so designed as to utilize as far as possible the old plant. The new plant consists of six mechanical filters in sets of three on each side of a pipe gallery, all under cover of a fireproof building. The head works from which a water supply is taken remains as originally designed and constructed. A 36-inch creosoted wood stave pipe was constructed to connect the head works with the storage reservoir. This pipe line supersedes a 20-inch line originally constructed to convey water from the head works to the old filter plant.

The storage reservoir, now settling basins, was completely remodeled. This basin is about 300 feet long and 100 feet wide. A reinforced concrete division wall was constructed across the basin dividing it into two basins, the smaller of which is of a capacity about one-quarter the total capacity of the basin. The bottom of the small basin was excavated hopper-shaped, floored with concrete and supplied with an independent drain pipe to the river. The small basin receives the raw water and is intended to afford a short period of sedimentation for the heavy sandy sediment carried by the river in freshets. A chemical house was constructed at the south end of the

[1] Presented before the Rocky Mountain Section meeting, February 8, 1927.

[2] Consulting Engineer, Kansas City, Mo.

division wall of this basin. In this house are located four coagulating dry feed machines, two for the application of hydrated lime and two for the application of alum or such other coagulant as may be used. These machines deposit the dry coagulant into the water entering the basement of the chemical house after sedimentation in the small division of the settling basin. After receiving the chemicals the water flows through different compartments in the basement of the chemical house and finally reaches the outlet pipe laid across the basin parallel with the division wall. Openings are made in this pipe of a size and so spaced as to give a substantially uniform distribution of the treated water the entire width of the larger of the two divisions of the basin. The treated water deposits coagulated sediment while flowing over 200 feet to the outlet where the water passes over a weir into the outlet chamber. From this chamber the water flows to both the old and the new filters through pipe lines, the larger of which is 30 inches in diameter. Both of the settling basins have concrete bottoms and are concrete lined. By-pass pipes are provided by which either basin can be emptied for cleaning without interfering with the operation of the works. These by-pass pipes are 36 inches in diameter of reinforced concrete.

The only novel feature about the settling basin is the adjustable weir gate over which the water from the small basin flows into the basement of the chemical house. This gate is made adjustable because the fluctuation of river level causes several feet variation in the operating level of the water in the settling basin. This weir gate is operated by a worm gear which permits the adjustment of the lip of the weir to any desirable level within the range of water level fluctuation.

The six filter units of the new filter plant were built independently of reinforced concrete, that is, there is no concrete bond between the units of the filter plant above the floor slab. Each filter unit has an area of 280 square feet and a rated filtering capacity of one million gallons daily, equivalent to a rate of $2\frac{1}{2}$ gallons per square foot per minute.

The manifold of each filter consists of a cast iron header 12 inches in diameter laid beneath the floor of the filter and cased in concrete, to which lateral pipes are bolted spaced 10 inches apart, of $2\frac{1}{2}$-inch Byers wrought iron pipe. Each lateral is perforated on the bottom with a row of $\frac{7}{16}$-inch holes spaced 6 inches apart. These holes, totaling 624 for each filter, admit filtered water into the manifold and

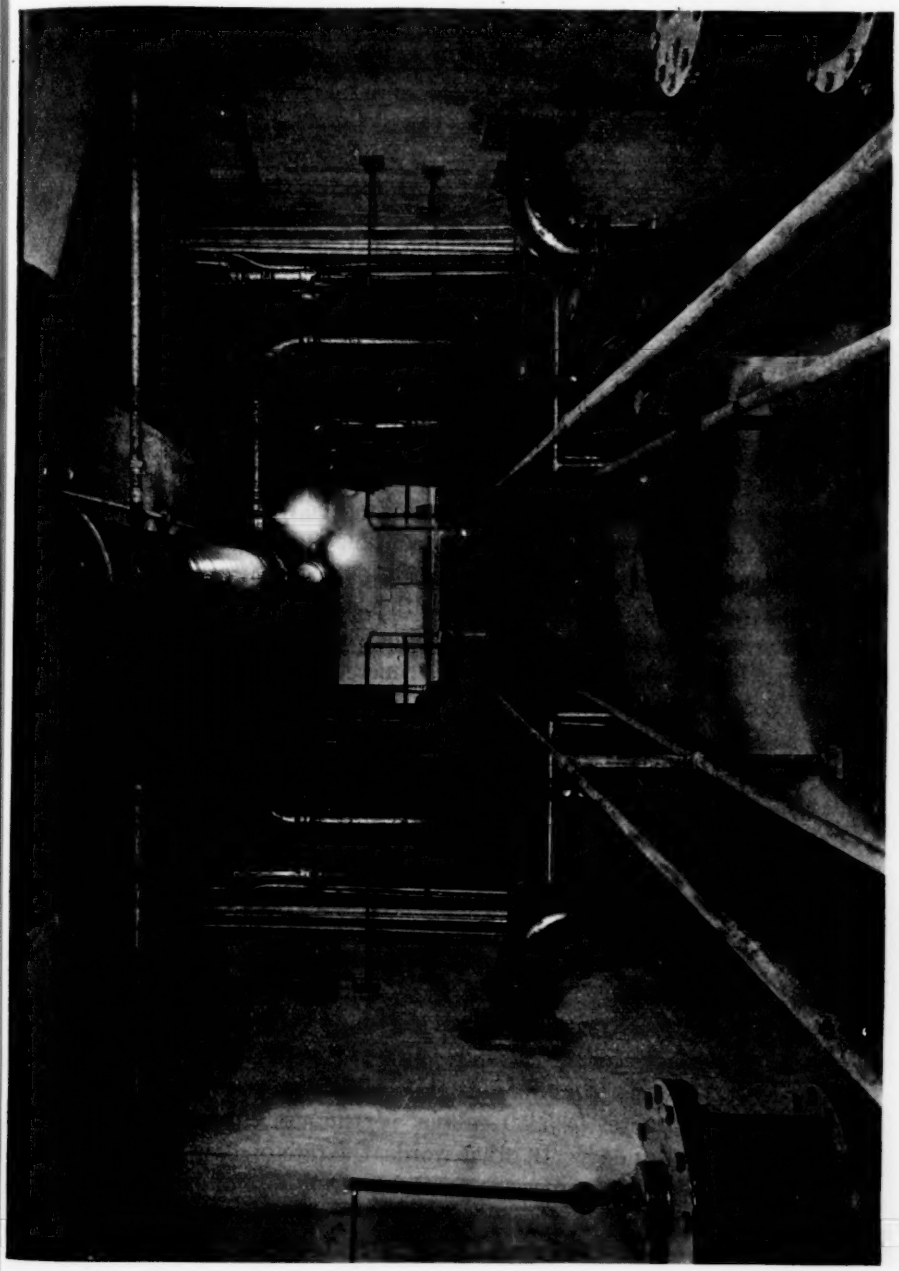

FIG. 1. PIPE GALLERY, FORT COLLINS FILTRATION PLANT

thence through the header into the outlet flume in the pipe gallery. They also admit water under the filter sand by reverse flow in washing the filter. These lateral pipes of the manifold are surrounded with 15 inches of graded gravel. On the top of the gravel is 30 inches of graded filter sand. The filter sand is bank sand obtained from a locality near Fort Collins, screened to conform to the usual specification for filter sand.

The pipe gallery is 12 feet wide with the level of the floor 5½ feet below the level of the bottom of the filter tanks. On the floor of the pipe gallery is a reinforced concrete flume with opening 4 feet square which receives the water from each of the six filter units. This flume is located centrally in the gallery and affords a clear passageway from end to end of the gallery. At the outlet end of the flume is a weir with overflow area above the weir for 12 filter units. Back of this weir is a pipe communicating with a still box and in the still box is a float actuating a recording device registering the depth of water over the weir to within $\frac{1}{16}$ inch and is susceptible of reading to one-half this amount.

Immediately above the flume, and with a clearance of 8 feet 9 inches between them, is the concrete inlet flume which admits water to the filters. This flume is of reinforced concrete with opening 3 feet wide, 3 feet 3 inches high, supported on concrete brackets molded monolithic with the filter tanks. An 8-inch pipe connects the inlet flume with each of the filters. This pipe has an elbow and 8-inch flanged nipple with the face of flange set level. To the face of this flange is bolted the monel metal orifice above described which controls the rate of flow into the filter under a uniform head of 6 inches; in other words, the level of the water in the inlet flume is 6 inches above the orifice plate.

Under the inlet flume a 12-inch wash water pipe is suspended and connected with a 12-inch branch pipe leading to the header of each of the filter units. The capacity of this pipe is sufficient for a discharge of wash water which will cause a rise in the filtered tub of at least 2 feet per minute. At this rate of rise the flow of water for washing purposes is 5250 gallons per minute equivalent to 7½ million gallons per day. In other words, the rate of flow during the washing inverval is 7½ times the normal filtering rate of each unit.

The wash water after passing upward through the sand is received in three cast iron lateral wash troughs, 20 feet long, spaced 4 feet 8 inches apart center to center and one-half this distance from the

side walls of the filter unit. The water from these lateral troughs is received into a main wash trough at the end of each filter unit next to the pipe gallery. From the main trough the water passes through a 16-inch drain valve into a 20-inch drain pipe leading to the river. The drain valve is what is known as a plug valve set flush with the bottom of the main wash trough. It is manipulated from the filter house floor level through a bevel geared valve stand.

In addition to the plug drain valve there are four other valves on each filter unit marked "Influent," "Effluent," "Wash," and "Rewash." All of these valves are hydraulically operated from an operating table set on the floor of the filter house. The water pressure for operating these valves is derived from a wash water tank constructed in earth excavation about 50 feet above the level of the filter room floor. This tank is a part of the original works and is of about 180,000 gallons capacity. A simple mechanism connecting each hydraulic valve with the operating table indicates the position and direction of motion of each valve. All of the hydraulic valves are in the pipe gallery between the outlet flume and the side walls of the filter, so adjusted and located as to be accessible from the top of the outlet flume. On the 8-inch outlet branch from the header of the manifold is placed the monel metal effluent control orifice between two conveniently located flanges of the effluent branch.

There is one departure from ordinary practice in the valve layout which perhaps is worthy of notice. The 6-inch rewash pipe discharges into the main wash water trough of each filter. Ordinarily this valve is made to discharge into the filter drain pipe. In the Ft. Collins case it is much more convenient to connect it directly with the main wash trough. The utility of this rewash pipe is doubtful. Its purpose is to waste filtered water from a filter immediately after washing for a period of 5 to 15 minutes, as the case may be, until the filter settles down to normal working conditions. This pipe and its connections could be entirely abandoned without affecting the efficiency of the filter, provided the operator is careful to let each filter unit stand until the coagulant and sediment remaining in the water after washing has settled upon the sand and then to bring the filter slowly up to its normal rating. Perhaps a period of half an hour might be required for this purpose. The rewash connection is therefore more of a safety device than a necessity.

The water from the outlet flume discharges over a weir into a chamber deep enough to receive water from the clear water basin

of the old filters. After the effluent of the two filter plants unite in this chamber the water flows over a second weir into an outlet chamber. A pipe connection on the upstream side of this second weir connects with a still well in which is a float actuating a recorder of the same size and character as that above described. In the outlet chamber the water enters a 30-inch gravity main leading to a distributing reservoir several miles distant. There is also a pipe connecting the outlet chamber with a third still well wherein the float operates an indicating gauge to indicate the level of the water at the outlet.

Each of these several outlet chambers extends 6 feet or more below low water level in the adjoining river. This is necessary owing to the deep excavation required for the pipe from clear water basin of the old filters. These filters are constructed with the tops of the filter tanks at ground level. The tops of the new filter tanks are 3 or 4 feet above the natural ground level. This deep construction providing for a connection to the old filter plant, has added considerably to the cost chargeable to the new plant.

A balcony is constructed around each filter unit on the same level as the floor which covers the pipe gallery. The pipe gallery is reasonably well lighted and thoroughly ventilated by openings in the floor over the gallery covered with metal subway grating.

The entire filter plant is housed in a brick building with steel windows and doors and roof girders. The roof is of Federal cement tile covered with 5 ply Barrett roof graveled. The trim of the building is of Bedford cut stone. The building is heated by a forced draft hot air furnace. The heated air penetrates all parts of the building, even into the pipe gallery through the grated openings above described and is drawn out through a duct in the pumping room basement.

The outlet chambers above described are covered with a heavy reinforced concrete floor, one flight of stairs below the level of the main filter room floor. This basement contains two motor driven filter wash water pumps and a turbine water wheel for keeping the wash water reservoir supplied with water. In the opposite end of the pump room basement is a chlorinator of the Wallace-Tiernan vacuum type which supplies liquid chlorine to the water as it passes into the outlet pipe leading to the distributing reservoir. Electricity is derived from a 110-volt Exide battery of 56 cells for light and power purposes. The water wheel is supplied with water through a 30-inch pipe about 2000 feet long.

The water from the settling basin enters the filter inlet flume through an inlet well on the outside of and adjoining the new filter building. A butterfly valve actuated by a worm gear is connected with the 30-inch inlet pipe inside the inlet well. The gear has an extension shaft passing through a sleeve to the inside of the filter house, by which the valve gate can be set at any angle. This valve enables the attendant to control the volume of incoming water and thereby to control the level of the water in the inlet flume. There is an overflow waste weir in the inlet well to prevent flooding of the filters.

The new filter plant is located about 15 feet south of the old filter plant. This space between the two plants has been constructed into a furnace cellar, coal storage room, and a bricked-in inclosure for the force draft fan and motor. The roof over the furnace basement is of reinforced concrete. A wing from the new filter building extends to a junction with the old filter building and affords a well lighted and convenient work room for the attendant over the furnace basement. The stairway leading into the furnace basement forms a vent for the warm air ascending from around the furnace sufficient to heat the work room. Toilet fixtures are also located in the wing of the building and connected with a sewer leading to a septic tank.

The cost of the filter plant was $135,972, equivalent to $22,662 per million gallons filtering capacity. Several factors contributed in an unusual degree to the cost of this plant, namely, deep excavation because of the union of the effluent from the old and the new filter plants and because of the small fall between the head works and the new plant; provision in the capacity of both the influent and effluent flumes for six additional filters; the use of a 16-inch wash water pipe part of the way in order to reinforce the washing facilities of the old filters as well as to furnish wash water for the new filters and any future extension of the new filter plant. Through the united effort of Mr. Lawver, City Engineer, and his assistants, Mr. Connell Resident Engineer and Messrs. Spotts & Malcom, Contractors, the construction work is a credit to all concerned. There is no record of operating costs as the filters are not yet in commission awaiting the completion of the pipe line connecting the new filters with the distributing reservoir.

PROTECTION OF WATER SERVICES IN EXPOSED LOCATIONS[1]

By S. D. Bleich[2]

It is in connection with the ventilation of the subway railroads in New York City that it became necessary in a number of instances to lay water services exposed to the atmosphere through the ventilating chambers. This resulted in studies and investigations to determine how such services should be insulated so that they may be as well protected against freezing as if they were normally laid in the ground.

The ventilation of the subway railroad is effected by arranging sufficient area of openings on the sidewalks at the curbs which lead into the subway through ventilating chambers. These openings are covered with steel gratings. The steel gratings are usually 4 feet wide and for a four-track subway occupy on each side of the street a length of approximately one-third the length of the railroad. The water mains are usually laid over the roof within the roadway except in rare cases where the pipes are too large for the available cover over the roof of the subway structure. In such cases the pipes are laid under the sidewalk between the subway structure and the building line.

Every effort is made to keep water and other services outside and independent of the subway structure. Where the water mains are under the sidewalk and adjacent to the subway, these services can be connected to the mains without carrying them through the subway ventilating chambers. But where the mains are located under the roadway, which is the usual case, interference frequently results between the ventilating chambers and the house services. The alternative arrangements have been used to avoid carrying the services through the subway structure. These are in the order of frequency in which they are used, as follows:

1. The length of the subway ventilators is split up by omitting one

[1] Presented before the Chicago Convention, June 10, 1927.

[2] Board of Transportation, New York, N. Y.

or two 5-foot bays of gratings at alternate lot lines through which the services of the two adjoining buildings are carried to the mains in the roadway. The surrounding earth and the concrete walls of the ventilators furnish the necessary insulation against freezing around the water services (see sketch *a* of figure 1).

2. The second method is to provide under the sidewalk between the ventilating chamber and the building line an auxiliary 4- or 6-inch water pipe in addition to the main in the roadway. The services

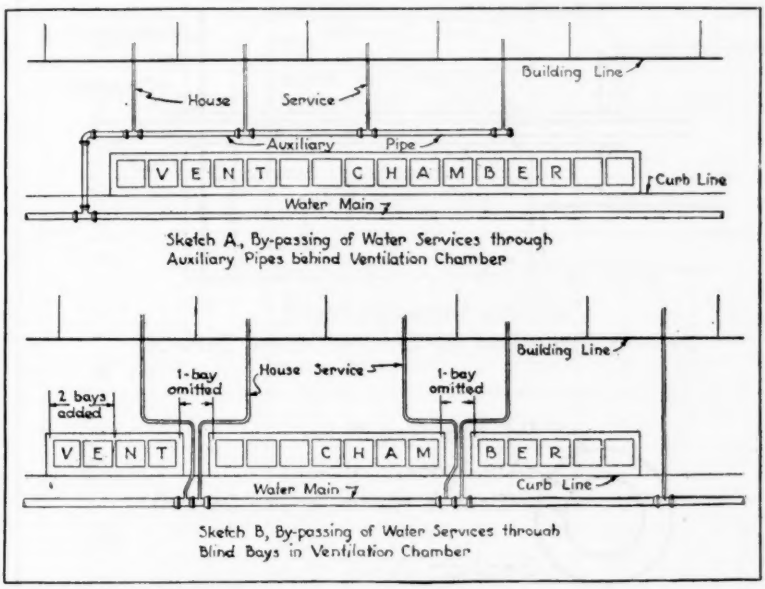

FIG. 1. METHODS OF PROVIDING PROTECTION AGAINST FREEZING OF SERVICES, WITHOUT AUXILIARY INSULATION

are then connected to the auxiliary pipe directly, thus the services are surrounded with the normal amount of earth protection. This method is not frequently used, as it complicates the water distribution system.

Although every effort is made to avoid carrying services through the subway ventilating chambers, it sometimes proves unavoidable and the water services as well as electric and gas services have to be carried through the ventilators exposed to the atmosphere. It then becomes necessary to protect the exposed water service pipes from freezing.

Extensive theoretical and experimental work was done by the engineers of the Board of Transportation to develop a design which would adequately protect the water services against freezing when exposed to extreme low temperatures for such periods as may occur, as indicated by the records of the Weather Bureau.

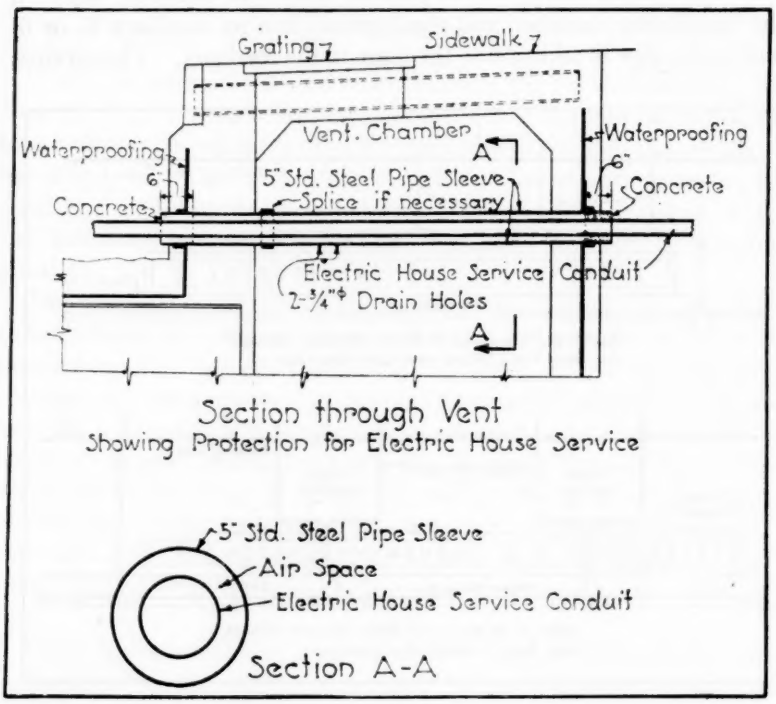

FIG. 2. PROTECTION FOR ELECTRIC HOUSE SERVICE PASSING THROUGH VENTILATING CHAMBER

Electric and gas services are usually carried in ferrules through ventilating chambers to protect them from injury and to facilitate replacement when necessary. This method is shown on figure 2.

Water services are usually $\frac{3}{4}$ to 1 inch in diameter and, if exposed to an outside temperature of 0° F., would freeze in less than three hours. If such services were carried in steel ferrules in the same manner as electric and gas services the air space and ferrules would only give an additional protection of about two hours against freezing.

This is insufficient, as atmospheric temperatures of 0° to minus 10°F. last frequently for much greater periods than five hours and water within the pipes is apt to remain unchanged overnight for homes and for two days (Sunday and one holiday) for business and industrial places.

①	②	③	④	⑤	⑥	⑦	⑧	⑨
Type	Insulation	Heat lost in Kgm. Calor per Hour per Deg. C.	Time in Hours: Outside Temp. 0°F.-Init. Temp. Water 40°F.			Outside Temp. -10°F.-Init. Temp. Water 40°F.		
			Water 40°F. to Ice 32°F.	Water 32°F. to Ice 32°F.	Total	Water 40°F. to Ice 32°F.	Water 32°F. to Ice 32°F.	Total
a	0.3 Watenproofing 3-1" Layers Hairfelt ¾" Service Pipe	0.098	0.6	13.1	13.7	0.5	10.1	10.6
b	1" Pipe 3-1" Layers Hairfelt ¾" Service Pipe	0.099	0.6	12.9	13.5	0.5	10.0	10.5
c	6" Pipe ¾" Pipe Air Space ¾" Service Pipe	0.180	0.3	7.1	7.4	0.3	5.4	5.7
d	1" Pipe Quartz sand ¾" Service Pipe	0.149	0.4	8.6	9.0	0.3	6.5	6.8
e	¼ Asphalt Paint 3-1" Layers Hairfelt ¾" Pipe (omitted for e') Air Space ¾" Service Pipe	0.0792	0.8	16.2	17.0	0.6	12.3	12.9
e'		0.098	0.6	13.1	13.7	0.5	10.1	10.6
f	2" Pipe 1¼ Pipe (omitted for f') 3-1" Layers Hairfelt Air Space ¾" Service Pipe	0.075	0.8	17.1	17.9	0.7	13.0	13.7
f'		0.092	0.7	14.0	14.7	0.6	10.6	11.2
g	4" Pipe Air Space 2" Service Pipe	0.43	1.0	21.0	22.0	0.8	16.0	16.8
h	5" Pipe Air Space 3" Service Pipe	0.575	1.7	35.6	37.3	1.4	27.3	28.7
k	6" Pipe Air Space 4" Service Pipe	0.723	2.5	50.0	52.5	2.0	38.4	40.4
l	¼ Asphalt Paint 3-1" Layers Hairfelt 2½ Ferrule (omit. for l') Air Space 2" Service Pipe	0.139	3.3	65.6	68.9	2.5	50.0	52.5
l'		0.148	3.0	61.0	64.0	2.4	47.6	50.0
m	¼ Asphalt Paint 3-1" Layers Hairfelt 3½ Ferrule (omit for m') Air Space 3" Service Pipe	0.172	5.9	117.8	123.7	4.6	91.2	95.8
m'		0.186	5.5	110.0	115.5	4.3	84.3	88.6
n	¼ Asphalt Paint 3-1" Layers Hairfelt Air Space 4½" Ferrule (omit. for n') 4" Service Pipe	0.204	8.9	178.5	187.4	7.0	136.5	143.5
n'		0.222	8.2	165.0	173.2	6.4	125.0	131.4

FIG. 3. EXPERIMENTAL FINDINGS IN STUDY OF INSULATION FOR WATER SERVICE PIPES AGAINST FREEZING

Special insulation must be provided which will prevent the water within services from freezing for a period of at least forty-eight hours, when the outside temperature remains the lowest, which for New York City is about 10° below zero Fahrenheit and the initial temperature of the water is 40° F, which corresponds approximately to its maximum density.

The theoretical calculations were based on the standard formula giving the loss of heat through a circular ring one unit in length during a unit of time of one hour for a difference in temperature of 1°C. when surrounded with one or more layers of insulating material. It was found convenient to use the metric system. The initial temperature of the water was taken at 40°F. or 4.4°C. The atmospheric temperature was taken in one set of calculations at 0°F. and in a second set of calculations an atmospheric temperature of −10°F. was used. For details of the calculations see figure 3.

The insulation serves to retard the transmission of heat from the water within the pipe to the outside atmosphere which is at a lower temperature. The effectiveness of the insulation is indicated by the low figure for the loss of heat given in column 3 of figure 3. The lower this figure the better the insulation. The figures in column 3 represent the loss of heat in one hour from the water within the pipe to the outside air in kilogram-calories for 1°C. difference in temperature between the water and atmosphere for a length of pipe of one meter. At the initial time, when the water in the pipe becomes at rest, we have the maximum difference in temperature between the water and the outside air and, therefore, the greatest rate of heat loss from the still water. As the temperature of the water falls, due to loss of heat, the difference in temperature becomes less and the rate of heat loss becomes correspondingly reduced, with the result that the time it takes for the water to drop from an initial difference in temperature T_2 to a difference in temperature T_1 in degrees Centigrade is represented by a logarithmic equation:

$$t_1 = \frac{q}{k} \text{ nap. log } \frac{T_2}{T_1} = \frac{q}{k} 2.3026 \log \frac{T_2}{T_1}$$

in which *nap. log* represents the Napierian logarithm and *log* represents Briggs logarithm; t_1 gives the time in hours; q is the quantity of water in kilograms in a meter length of pipe; and k is the loss of heat in kilogram-calories per hour for the type of insulation considered for a meter length of pipe for 1°C. difference in temperature, as given in column 3 of figure 3.

This process of falling temperature continues until the water within the pipe becomes 0°C., when freezing begins. The time for the temperature of the water to fall from 4.4° to 0°C. is computed by the logarithmic formula just given and the results are recorded in column 4 for the various types of insulations for an outside temperature of 0°F., and in column 7 for an outside temperature of −10°F.

TABLE 1

Experimental results of freezing time for various insulations on 1-inch lead pipe

TEST NUMBER	INSULATION	TEMPERATURE		TIME		
		Initial water	Outside	To 32° water	32° water to 32° ice	Total
		°F.	°F.	*hours*	*hours*	*hours*
1	No insulation	40	6.5	0.5	3.0	3.5
			0	—	—	2.8
2	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe	40	8.5	1.0	9.0	10.0
			0	—	—	7.3
3	3-inch hairfelt	40	2.0	2.0	7.5	9.5
			0	—	—	8.9
4	3-inch Flaxlinum (coarse flax fibre)	40	8.5	2.0	11.0	13.0
			0	—	—	9.5
5	3-inch Armorak (alternate layers ½-inch hairfelt and tar paper)	40	2.5	2.5	9.0	11.5
			0	—	—	10.6
6	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe, 3-inch Armorak	40	2.0	5.0	10.0	15.0
			0	—	—	14.1
7	4-inch Armorak	40	4.0	5.0	12.0	17.0
			0	—	—	14.9
8	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe, 4-inch Armorak	40	3.5	5.5	21.5	27.0
			0	—	—	24.0
9	3-inch woolfelt covering, 2 plies rubberoid roofing	40	4.0	2.5	12.5	15.0
			0	—	—	14.1
10	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe, 3-inch woolfelt	40	4.0	4.0	14.0	18.0
			0	—	—	15.8
11	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe, 2¾-inch tar paper	40	3.0	4.5	9.0	13.5
			0	—	—	12.2
12	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe, 1-inch woolfelt; 1-inch hairfelt, 1-inch tar paper	40	6.0	5.5	7.5	13.0
			0	—	—	10.6
13	3-inch 85 per cent magnesia covering, 3 plies rubber roofing	40	3.5	2.0	6.0	8.0
			0	—	—	7.1

TABLE 1—*Continued*

TEST NUMBER	INSULATION	TEMPERATURE		TIME		
		Initial water	Outside	To 32° water	32° water to 32° ice	Total
		°F.	°F.	*hours*	*hours*	*hours*
14	4-inch powdered cork, 1-inch board box	40	4.0	4.0	20.0	24.0
			0	—	—	21.0
15	3-inch cork mastic (granulated cork and asphalt) 1-inch board box	40	3.0	3.5	4.0	7.5
			0	—	—	6.8
16	1-inch hairfelt, ¼-inch air space, 4-inch wrought iron pipe; 3¼-inch Nonparial compressed cork	40	2.0	4.5	12.5	17.0
			0	—	—	16.0
17	3-inch pine sawdust, 1-inch board box	40	6.0	3.0	7.0	10.0
			0	—	—	8.1
18	1-inch hairfelt, 3½-inch wood (rectangular box)	40	4.0	3.5	13.0	16.5
			0	—	—	14.4
19	3¼-inch horse manure, 1-inch board box	40	3.5	4.0	18.0	22.0
			0	—	—	19.6

After the freezing temperature of the water is reached, the temperature of the water remains constant during the freezing or crystallization process during which the heat is lost from the water until all the water within the pipe is converted into ice. The time in hours required for freezing at the freezing temperature is:

$$t_2 = \frac{80q}{kT_1}$$

in which T is the temperature of the atmosphere below 0°C., and q and k are the same as in the formula given for t_1. 80 represents the latent heat of freezing. The results of t_2 are given in columns 5 and 8 of figure 3. The total time of freezing from the initial temperatures of water 4.4°C. (40°F.) is the sum of t_1 and t_2 and is given in columns 6 and 9 of figure 3.

The tests on various insulating materials on water services were

made in one of the refrigerating rooms of the Manhattan Refrigerating Company at No. 525 West Street, New York City.

The insulating materials and lead pipe were furnished by the Robert A. Keasby Company, gratis, at West and Bank Streets, New York City.

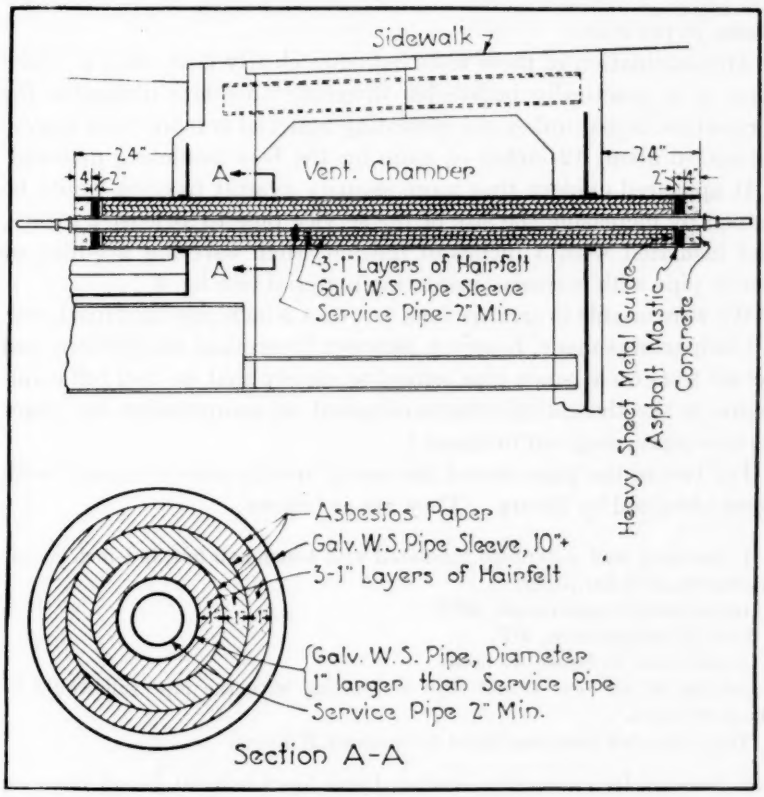

FIG. 4. METHOD OF INSULATION FOR WATER SERVICES CARRIED THROUGH VENTILATION CHAMBER

The lead pipe was 1 inch in diameter, and, to allow for expansion of the water during freezing, the pipe was only 0.8 filled. The initial temperature of the water was 4°C. (40°F.), which is a temperature of maximum water density.

The temperature of the refrigerating room varied at different times from 0° to 8.5°F.

Temperature readings of the water within the pipe were taken periodically, from which the time it took for the temperature of the water to fall to 32°F. without freezing was determined. These results are given in table 1 for the various insulating materials described.

Due to the fact that the pipe was not entirely filled with water, the times of freezing given in these tables should be increased by about 16 per cent.

An examination of these tests indicates clearly that, with a 1-inch pipe, it is practically impossible to secure adequate insulation for forty-eight hours, unless the insulating material is made very heavy, estimated about 12 inches or more for the best insulating material.

It appeared evident that more security against freezing would be gained by increasing the size of the service pipe to at least 2 inches, and insulated with 3 inches of hairfelt, than covering a $\frac{3}{4}$-inch or 1-inch pipe with excessive insulating material (see fig. 4).

We were unable to arrange for a test on a 2-inch pipe thus insulated.

Comparisons made, however, between theoretical calculations and actual tests on a 1-inch pipe agreed so closely that we had full confidence in the theoretical results obtained on computation for larger service pipes, as given in figure 1.

For two of the pipes tested the actual results were compared with those obtained by theory. They are as follows:

1. One-inch lead water pipe, insulated with 4-inch hair felt, in $\frac{1}{2}$-inch layers, alternated with tar paper.

Initial water temperature, 40°F.

Outside temperature, 4°F.

Actual time to freeze, 17 hours.

Adding 16 per cent actual time of freezing with the pipe full would be about 20 hours.

The computed time was found to be about 27 hours.

2. One-inch lead water pipe, insulated with 1-inch hair felt, $\frac{1}{4}$-inch air space.

Four-inch wrought iron pipe and 4-inches of hair felt, in $\frac{1}{2}$-inch layers, separated with tar paper.

Initial temperature of water, 40°F.

Outside temperature, 3.5°F.

Actual time to freeze, 27 hours, plus 16 per cent, equals 31.5 hours.

The theoretical time was found to be 29.9 hours.

The discrepancy between the actual and computed time may be due to a different hair felt having been used than that assumed in the computations, thereby giving a different constant of conductivity; also, the correction of 16 per cent made in the test is approximate only.

The type of insulation finally adopted for protecting water services against freezing when located in exposed places is shown on figure 4. The water service is increased to at least 2 inches in diameter carried through an insulated ferrule consisting of an inner galvanized steel pipe surrounded with three layers of 1-inch hairfelt separated by asbestos paper and the whole protected from injury with an outer galvanized steel pipe. This type of construction is extended at least 2 feet into the adjoining ground. The ends of the insulated ferrule are sealed with asphalt mastic and concrete.

COÖPERATIVE STATE CONTROL OF PHENOL WASTES ON THE OHIO RIVER WATERSHED[1]

By E. S. Tisdale[2]

Excessive rainfall on the watershed of the Ohio and Mississippi Rivers has at this time brought about the most disastrous floods in history of the valley of the Mississippi River. Loss of lives and destruction of property mounting into billions of dollars will focus the attention upon the need of flood prevention measures to forestall another such disaster.

On the Ohio River, a large tributary of the Mississippi, great damage to certain public water supplies was imminent five years ago, not from excessive floods, as is now the case on the Mississippi River, but on account of a new type of industrial waste pollution discharged in increasing amounts into streams on the Ohio River watershed. The phenol and tar acid wastes from by-product coke plants had a power of enormous penetration and in extraordinarily great dilution caused offensive tastes and odors in public water supplies taken from the streams into which these wastes were discharged.

In the State of Ohio alone in 1922 this new type of trade waste pollution bid fair to damage 40 per cent of the public water supplies and to affect detrimentally more than 50 public water supplies in the six states down stream. The purpose of this brief paper is threefold:

1. To indicate the magnitude and type of this industrial waste pollution which menaced public water supplies in Ohio, West Virginia and Pennsylvania.
2. To outline the methods taken to cope with them, namely, state coöperation with the adoption of a similar policy toward the industry.
3. To show the final result achieved, namely, practical elimination of phenol wastes from the Ohio River watershed and the birth of a new era in stream pollution control.

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[1] Presented before the Water Purification Division, Chicago Convention, June 10, 1927.

[2] Chief Engineer, State Department of Health, Charleston, W. Va.

THE TYPE AND MAGNITUDE OF PHENOL WASTES POLLUTION

The four splendid progress reports for the years 1923 to 1926 by the American Water Works Association Committee on Industrial Wastes in Relation to Water Supply, made by Chairman Almon L. Fales, set forth concisely and completely the growth and extent of industrial waste pollution in the United States. The relative importance which phenol wastes were assuming is indicated by the fact that one-third of the last report for the year 1926 was devoted to a discussion of phenol wastes and the difficulties met in public water supplies due to increasing prevalence of objectionable tastes occasioned by the rapid growth of the by-product coke industry. The nauseating, medicinal taste caused by this waste, even in minute quantities when combined with the chlorine used in water purification processes, was one of the outstanding characteristics of the problem.

H. R. Crohurst, sanitary engineer for the United States Public Health Service in 1924, who made a careful investigation of the extent of phenol pollution as a national question, estimated that 1 part of phenol waste to 75 or 100 million parts of chlorinated water was the common minimum dilution at which tastes and odors would be detected. Following his investigation he reported that 19 by-product coke plants were located on the highly industrialized upper Ohio River basin in West Virginia, Ohio and Pennsylvania discharging phenol bearing wastes into the river. He further showed that damage was then being caused to 34 public water supplies in five states down stream and 24 more water supplies might reasonably be expected to have trouble in the future. The pollution problems were common to several states and the phenol wastes had the power of causing objectionable tastes and odors even in minute quantities. This new type of pollution was due to expansion and growth in the by-product coke industry.

R. D. Leitch, chemical engineer for the United States Bureau of Mines, has indicated the magnitude of the by-product coke industry in a recent report. He states that, in 1923, 37 million tons of the 55 million net tons of coke were produced from by-product coke ovens. He estimated that 38 million tons of still wastes were produced annually and before the remedial work brought about by a state coöperation control program, about 75 per cent of these phenol-bearing wastes were discharged directly into the streams.

The remaining wastes were disposed of by coke quenching processes, the largest plants employing this method of treatment being located in Pennsylvania where the State Health Department had been actively working with the industries to prevent damage to public water supplies.

THE FIRST BEGINNINGS OF STATE COÖPERATION—PHENOL ELIMINATION ON THE OHIO WATERSHED

The underlying keynote in the method adopted to cope with control of phenol wastes was "interstate coöperation." Basic facts were first obtained by a careful study of the Sanitary Engineering Divisions in the three most affected states. All parties concerned were then called into the conference and a basic policy adopted. Careful investigation indicated that phenol wastes discharged into the Monongahela River in West Virginia were causing tastes in Pennsylvania's public water supplies derived from this river. Pennsylvania's by-product coke plants discharging tarry phenol wastes to the Ohio River in Pennsylvania were harming both Ohio and West Virginia public water supplies, along the Ohio below the Pennsylvania line and the Beaver River and its tributaries were grossly polluted by phenol wastes in Ohio before this stream entered Pennsylvania, where it is used for public water supply purposes. Public water supply intakes and phenol waste discharge outfalls are closely enmeshed on this highly industrialized watershed. Public health statesmanship and salesmanship of a high order were called for in coping with the problem and from the Ohio State Health Department came the initiative to unravel this public water supply and objectionable industrial waste tangle. We shall list consecutively the main steps leading up to the interstate agreement of 1924 between Ohio, Pennsylvania and West Virginia, which had as its main object, the elimination of phenol wastes from the Ohio River watershed.

First step

A dramatic phenol waste taste demonstration took place in 1922 when Cleveland's public water supply developed nauseating medicinal tastes so that it was unfit for drinking purposes due to pollution from by-product coke works on the Cuyahoga River. These wastes were carried by ice and wind currents out into Lake Erie $4\frac{1}{2}$ miles to Cleveland's water supply intake. Dr. J. E. Monger,

Director of Health, and W. H. Dittoe, then Chief Engineer of the Ohio State Health Department, following this occurrence, took the initiative in thrashing out the question of taste producing wastes and their damaging effect upon public water supplies. At the request of the Ohio Department of Health, Surgeon General Cumming of the United States Public Health Service in May, 1923, called the first phenol conference at Washington, D. C., to take testimony in the case and evaluate the problem from a national standpoint. Fifteen State Health Departments and representatives from the United States Bureau of Mines, United States Bureau of Standards and United States Public Health Service were present at this first meeting.

Second step

June, 1923, one month later, witnessed a group meeting at Cleveland, Ohio, where executives of the by-product coke companies of this state met with the Ohio Health Department and agreed upon a policy to keep the phenol wastes out of the streams of Ohio. The by-product coke companies of Ohio here agreed to coöperate with the Ohio Health Department, either to keep the phenols out of the stream entirely by a closed system or by treatment to eliminate the phenols from the wastes discharged. The coke companies stated that in all fairness to them the same policy should also apply to by-product coke companies in neighboring states. To try and expand the scope of the policy adopted between industry and the Ohio Health Department was the purpose of the following conference at Washington, D. C.

Third step

A group of interested states met in Washington at a conference called by Surgeon General Cumming in January, 1924. Here an organization of the states on the Ohio River watershed was effected. Dr. J. E. Monger, Director of Health of Ohio, was elected chairman, and the writer served as secretary. The principle which has been enunciated with respect to industrial waste disposal matters in a recent report by Leitch of the United States Bureau of Mines, was here discussed. *"Good judgment should be used in not burdening industries within one state with large expenses for purification until adjoining states have established similar regulations. No real results can be accomplished until all affected are working in unison along the*

same lines and under similar regulations." Following this second national phenol conference, Sanitary Engineer Crohurst, of the United States Public Health Service, was detailed to make his accurate study of the extent of phenol waste pollution from a national standpoint, the cause, and the damage being done to public water supplies in the United States.

Fourth step

The scene next shifted to Pittsburgh, Pa., where on April 14, 1924, all the State Health Departments most interested, namely, Pennsylvania, Ohio, New York and West Virginia, met in conference with executives from all the by-product coke manufacturers from the several states to hear and discuss the report of United States Public Health Service and to formulate *joint similar policies* for coöperating states to carry out working with the industries. The position assumed by the leading steel and by-product coke companies of the country, and which was set forth by Mr. Elbert H. Gary of the United States Steel Corporation, was that the steel companies should coöperate with the State Health Departments even though large financial investments were necessary to collect and evaporate these objectionable phenol wastes by coke quenching. Phenol treatment plants to remove the phenol from the wastes were deemed necessary where the coke was produced for the domestic market and the coke not used in the steel industry itself.

The Interstate Stream Conservation Agreement of 1924

On November 17, 1924, three State Health Departments, Pennsylvania, Ohio and West Virginia, acting through their respective Health Commissioners, entered into and signed an agreement to inaugurate and carry out joint similar policies with respect to phenol waste disposal. Under this agreement substantially complete elimination of discharge of phenol wastes into streams on the Ohio River watershed of these three states was called for. The aim of the agreement was to correct and prevent undue pollution of the interstate streams so that these streams might be maintained as suitable sources of public water supplies.

PROGRESS IN PHENOL WASTES ELIMINATION

On February 18, 1926, the states in conference at Pittsburgh took stock on progress made, at which time the State of Kentucky was

added to the group and became a signatory to the agreement. The progress since 1924 was found to be substantially as follows:

Pennsylvania: Of the six plants in Pennsylvania, four were disposing of phenol wastes satisfactorily by closed systems or lagoons, one plant had been dismantled and one was still discharging wastes to the Ohio River.

Ohio: Of the seven plants in Ohio, all had agreed to handle wastes satisfactorily and were in process of constructing the systems. Three companies were handling wastes so as to prevent discharge. Two new plants were planned and had agreed to use the closed system, putting no wastes into the rivers, in accordance with the new policy and agreement.

West Virginia: Of the six plants in West Virginia changes were in process at two plants to keep wastes out of stream. Two new plants were being built to conform with the new policy of handling phenol wastes. Two plants were still discharging phenol to the streams.

THE FINAL CHECK ON PHENOL WASTES ELIMINATION BY STATE ENGINEERS

On April 1, 1927, a survey by sanitary engineers of the respective states indicated that the single remaining Pennsylvania plant had agreed to proceed with a phenol wastes treatment works upon recommendations from the Sanitary Water Board of Pennsylvania. Ohio reported that phenol had been practically 100 per cent eliminated from the rivers. However, in one case, the treatment adopted was not satisfactory and a new, more efficient process would be installed. West Virginia reported that, of the plants formerly discharging into the Ohio and Monongahela Rivers, two were using coke quenching processes and the other had completed a phenol wastes treatment plant. Compliance with new policy was complete in West Virginia, except for one plant which promised to proceed as soon as the most practical treatment method could be determined upon. Of the 21 phenol wastes plants which were on the watershed, only one remained not complying with the recommendations of the Interstate Stream Conversation Agreement of November, 1924. It appears that coöperation between states to carry out one definite policy has been remarkably effective in reducing phenol pollution of the Ohio River watershed.

THE BIRTH OF A NEW ERA—COÖPERATION BETWEEN STATES AND INDUSTRY

Success in eliminating the objectionable phenols has lead to the formation of plans by nine states on Ohio River watershed to in-

augurate and practice similar policies with respect to other stream pollution matters. The original group of three State Health Departments is now enlarged to nine State Health Departments. These states, Pennsylvania, Ohio, West Virginia, Kentucky, New York, Maryland, Indiana, Illinois and Tennessee all are included in the Ohio River basin. In conference at Pittsburgh, September 27, 1926, all became signatories to the Interstate Stream Conservation Agreement. During the meeting the State Health Commissioners created a board of engineers of the signatory State Health Departments who should report to the Health Commissioners ways and means to make the agreement effective. Mr. W. L. Stevenson, Chief Engineer, Pennsylvania State Health Department, was named chairman and Mr. F. H. Waring, Chief Engineer, Ohio Department of Health, secretary. The group of the chief sanitary engineers of 9 states on the Ohio River watershed, where 15 millions of people live, met for the first time on April 29, 1927, in Columbus, Ohio, and organized as the "Board of Public Health Engineers, Ohio River Basin."

The recent progress achieved in eliminating objectionable phenol wastes by coöperation of states with industry has been so marked that the cry for "federal control of stream pollution" is becoming less insistent. Among the recommendations in the recent report of the Secretary of War dated June 4, 1926, and included as Document 417, 69th Congress, First Session, House of Representatives, is found the following:

> Because of the activity and steady progress of the states, manufacturers and industries in improving conditions, no federal legislation is recommended at this time so far as the effect of pollution on fisheries is concerned.

Dr. W. H. Frost of the United States Public Health Service, whose extensive stream pollution studies of the Ohio River over a period of years have recently been published, has stated that this concerted effort of states coöperating with industry on a common policy relating to the treatment of objectionable industrial wastes, gives infinitely more promise of success than the enactment of federal laws to regulate the pollution of interstate streams.

The Board of Public Health Engineers, Ohio River Basin, the new infant which was born as a result of the pains and efforts to conquer phenol pollution on the Ohio River, is headed by two sanitary engineers who are now engaged in the application of coöperative methods on industrial wastes disposal between State and Industry.

Mr. W. L. Stevenson, chairman, is chief engineer of Pennsylvania State Department of Health and the Secretary of the Sanitary Water Board of Pennsylvania. In that capacity he is constantly meeting with and inaugurating coöperative policies with different industrial groups to work out the most practical methods of wastes disposal. Full scale experimental work on disposal of tannery wastes now being carried on by the Sanitary Water Board indicates that Pennsylvania is actively coöperating with her industries.

Mr. F. H. Waring, secretary, is chief engineer for Ohio State Health Department, which department has during 1926 been carrying on the group system of dealing with industrial companies which have troublesome waste products to handle. The canning group in Ohio have already made substantial progress in arriving at a standard for treatment acceptable to the state. The acid iron group, the milk and milk products and pulp and paper mill wastes group have also indicated their willingness to coöperate with the State Health Departments.

The Board of Public Health Engineers, Ohio River Basin, at the conclusion of their meeting in Columbus on April 29, 1927, drew up a report for the consideration of the 9 State Health Commissioners signatory to the Ohio River Interstate Stream Conservation Agreement, suggesting definite policies which the Board felt would entirely clean up the little ends of the phenol pollution and expand the coöperative method and relationship between state and industry on industrial wastes disposal, to the end that the Ohio River and its tributaries may be conserved for future generations in condition fit for use as a source of public water supplies.

DISCUSSION

NORMAN F. PRINCE:[3] Early this spring, 1927, the Company that I represent received a complaint regarding the discharge, into the Genesee River, of the effluents from the gas manufacturing processes.

These effluents were analyzed and the results proved very interesting. By far the worst offender was the effluent known as "ammonia still waste."

The volume of this waste per day is 19,550 gallons and the phenol and phenolic bodies contained therein is 349.3 pounds, all calculated as C_6H_5OH.

[3] Chemist and Engineer, Rochester Gas and Electric Corporation, Rochester, N. Y.

The total amount of phenol as C_6H_5OH discharged from the plant in all effluents is 398.38 pounds per day.

When this complaint was received we immediately started to work with the object of introducing our effluents, especially those containing phenol or phenolic bodies, into the municipal sewerage system rather than to continue discharging them into the Genesee River as we had done for so many years. This was at the suggestion of Mr. Devendorf, Division of Sanitation, New York State Department of Health.

As this work progressed we were gratified to learn that the introduction of phenolic bearing wastes into raw sewage in no way interfered with the bacterial growth in the sewage.

This work is comparatively recent so it is not complete as yet.

The distance from our plant to the main sewage disposal plant is about $5\frac{1}{2}$ miles. I cannot give you the size of the sewers, but we have a two to three hour contact from our plant to the main disposal plant.

We believe that this contact between phenol bearing liquors and sewage is advantageous in that the organic matter present has an opportunity to act upon the wastes.

Our work up to this time has been carried out on "Raw Sewage" as it enters the plant. We are now going ahead and introducing ammonia still waste directly into an Imhoff tank having a capacity of 500,000 gallons sewage per day. Into this tank we are introducing 500 gallons of ammonia still waste, which you will remember I classified as the worst offender. This will give a comparative condition of 1 gallon of still waste to 1000 gallons raw sewage, which ratio exists in the larger plant, i.e., 20 million gallons sewage to 20,000 gallons of still waste. 20,000 gallons per day is our maximum figure and 20 million gallons per day is the sewage plant minimum.

As this study is coöperative in every detail the results will undoubtedly be published and, if as we hope, there is a real value in it, it will be available at that time.

There are no special features that I want to bring out at this time, except that in considering some of these wastes it must be borne in mind that in addition to phenols they also contain sulphides and cyanogen compounds.

I do not believe this organization is "tied in" in any way with the American Gas Association. I have only been a member about four months myself, but I believe that the problem of disposal of gas

plant effluents is too big for any single municipality or privately owned corporation to take up and push through. The problem is too large. I think that it is important to all of you.

I am speaking now from the standpoint of a gas manufacturing company which manufactures coke as a neccessary side line. We have to manufacture coke to make coal gas and the fraction of a cent per thousand which is added to our cost eventually hits your pocket as a consumer of gas. We have to get the money from some place.

The Public Service Commission usually takes good care of us, and in considering any methods of disposal of waste I believe the close coöperation of all of the major organizations of the country should be sought and the economic features and adaptability of any process should be worked out thoroughly and sanely.

The process of quenching coke with phenol bearing wastes is in my opinion one of the most objectionable things that could be inflicted on any community because we simply delay the time of getting them into the water supply.

The temperature of incandescent coke is very high and when quenched with these wastes they are simply scattered over the immediate and sometimes distant neighborhoods if the winds are right. These phenolic bodies also return with soil drainage.

They finally get into the river or lakes anyway.

Our plant is located in the heart of a city. Twenty or thirty years ago we were out of the city. The place was known as "Smoky Hollow," but now all around us are plants and less than half a mile away are homes. We are just so situated that if we become a nuisance from one cause or another we have simply got to take care of that nuisance and not run away from it.

I believe that this organization, through coöperation, can do a great deal toward solving this problem which is a nuisance. We admit we are a nuisance, but we have heretofore had no other place to put our wastes.

I know that the American gas industry as a whole considers the proposition of phenol bearing wastes as one of great importance. There is not a plant of any size in this country that is not being more or less worried by that very thing, not harassed, but worried and they are worrying because they know it is objectionable.

CHAIRMAN HOWARD: I should like to ask Mr. Prince, what led to the research work in Rochester?

MR. PRINCE:[3] We have not altered the condition as yet. There is still research going on. The complaint was very good naturedly brought to us and we, just as good naturedly, took it up and went to work on it. I am not prepared to tell you all about the work because we want to clean up our own back yard first. I really think if we can get our own part of it cleaned up that the other manufacturers will follow suit.

WELLINGTON DONALDSON:[4] I can add very little to this discussion. The problems with which I am familiar are ones which have been brought out. The method of control has been condemned very severely it seems to me. I have seen coke-quenching methods used a good deal in western Pennsylvania, and so far as the stream is concerned I should say they are moderately successful as compared with the old conditions.

JAMES M. CAIRD:[5] I wish to publicly express my appreciation of the coöperation which we have had from the Rochester Gas & Electric Company, and also the city of Rochester in affording facilities by which these phenol waste studies and their disposal are being investigated.

The history of the case is that the Rochester and Lake Ontario Water Company have from time to time received serious complaints regarding the flavor of the water. It would be impossible to state just what those flavors are. Everybody who takes a drink has a different definition of it.

The study reverts a good deal to wind directions. The Genesee River extends quite a distance into Lake Ontario. The intake of the Rochester Lake Ontario Water Company is about 4500 feet out into the lake and about a mile and a quarter to the west of the Genesee River where it is discharged into the lake. When we get an east wind we get a flavor, and when the wind shifts again we get a back lash. We have been trying various methods to overcome some of these flavors. I think up to a certain extent we have been fairly successful in that we have been using potassium permanganate, the quantity varying somewhat with the intensity of the flavors. Our chief engineer at the pumping station developed a very ingenious device for applying this potassium permanganate. When we have

[4] With Fuller and McClintock, Consulting Engineers, New York, N. Y.
[5] Chemist and Bacteriologist, Troy, N. Y.

these winds and our troubles are coming back to us we immediately try to get into action and head them off. We apply the potassium permanganate to the water before it goes to the coagulation basin, and to a certain extent we have been able to eliminate some of these troubles, but we have not taken all of the flavor out. With a fine taste you can sometimes get a little flavor. The public has not been as critical lately as they have been in the past and the work that is being done by the Rochester Company together with the city I believe will bear fruit.

C. R. Cox:[6] The Hudson Valley Coke and Products Corporation operates a large by-product coke plant at Troy, N. Y., about 6 miles above the Hudson River intake of the water supply system owned by the Rensselaer Water Company. The State Department of Health, therefore, required that a phenol recovery plant be installed at the coke works before the manufacture of coke was started, as this corporation did not wish to quench their coke by the "closed system," thereby evaporating the phenol. The phenol recovery plant installed as a result of this requirement has been described in chemical literature, but not in any of the waterworks journals. It may be of interest, therefore, to give a brief description of this phenol recovery plant.

Ammonia liquors containing the phenol from the primary gas scrubbers of the coke plant are passed through benzol scrubbers where phenol is absorbed by the benzol. The benzol is then pumped through caustic soda scrubbers where the phenol reacts with the caustic soda to form sodium phenolate. The sodium phenolate is then treated with sulfuric acid to liberate the phenols, sodium sulfate being also formed by the reaction. The dephenolated benzol is used over again in the scrubbers and thus the process is continuous.

Rather poor efficiencies were secured at first, due to the fact that the caustic soda reacted with the carbon dioxide also removed with the phenols so that sodium carbonate was formed. A water scrubber was inserted, therefore, at a later date between the benzol scrubbers and the caustic soda scrubbers, so the caustic soda solution could be used for much longer periods. The actual efficiencies in the removal of phenols have varied from 70 to 98 per cent, frequently averaging 90 to 95 per cent for several weeks. These efficiencies are not altogether satisfactory, because, with an assumed efficiency of 85 per cent, about

[6] Division of Sanitation, State Department of Health, Albany, N. Y.

30 pounds of phenol are discharged into the Hudson River per day. These phenols do not mix thoroughly with the river flow but pass down the river toward the water supply intake and thus have led to difficulties at intervals.

The Rensselaer water filtration plant consists of typical mechanical filters where double chlorination is practiced, due to the heavy pollution of the Hudson River. The dose of chlorine added is very heavy, especially during the winter months when the river is covered with ice and the stream flow is at a minimum. Difficulties due to chlorophenol tastes have been met with, therefore, at times since the coke plant has been in operation. These difficulties could be traced to the inefficiency of the phenol recovery plant at first, but at other times it was difficult to explain the prevalence of chlorophenol tastes in the chlorinated river water. As the filtration plant is operated only at night, the State Department of Health suggested that the coke plant discharge the wastes containing residual phenols into the river between 6 a.m. and 12 noon. This precaution has been quite successful, although it would be very advisable for the phenol recovery to be made more efficient. The Hudson Valley Coke and Products Corporation, therefore, is investigating the problem.

Since the above discussion was held, it has been ascertained as a result of these studies that the relatively poor efficiencies of the existing plant have been due to the fact that emulsions are formed in the benzol scrubber which prevent the efficient absorption of the phenols. The designer of the phenol recovery plant has developed a modified design wherein the benzol has been replaced as an absorbing medium by tar oils made by the fractional distillation of coke plant tars. The preliminary work seems to indicate that this modified plant will produce much higher efficiencies of phenol recovery than the older plant.

CHAIRMAN HOWARD: Mr. Cox, where is that described?

MR. COX:[3] The phenol recovery plant mentioned above is described in the March, 1926, issue of *Industrial and Engineering Chemistry*. The improved plant is described in the September, 1927, number of the same journal.

PROGRESS IN CONTROL OF OIL POLLUTION[1]

By Almon L. Fales[2]

The Committee on Industrial Wastes in Relation to Water Supply, of which the writer is Chairman, has made four progress reports which have been published in the Journal, one each year for the last four years. It was decided by the Council on Standardization that instead of presenting another progress report this year, the time be devoted to individual papers of interest within the field covered by this Committee. The writer was requested to present a paper on progress in control of oil pollution.

OIL POLLUTION IN RELATION TO WATER SUPPLY

The first progress report of the Committee on Industrial Wastes in Relation to Water Supply (1) cited a considerable number of water supplies that had been injuriously affected by discharges from oil wells and oil refineries.

Pollution from oil wells. The trouble from oil wells is due to the discharge of oil and salt water. The crude oil may be separated from the water by a suitable skimming tank used in connection with the purification plant. If allowed to escape into a water supply, the oil imparts to the water a disagreeable taste and odor and interferes with coagulation, filtration and chlorination processes, increasing water purification expense. The salt water increases the hardness of the water supply and gives the water a brackish taste. Water supplies have been ruined in this way. It is impracticable to remedy the trouble by treatment of the water. When the pollution reaches the limit of tolerance, it is necessary to secure a new water supply.

F. M. Veatch, Consulting Engineer of Kansas City, has informed the writer that considerable progress has been made in Kansas in the care of salt water from drilling operations. In one of the Kansas fields, it has been found practicable to pump the salt water back into the water sand through the annular space between the strings

[1] Presented before the Water Purification Division, Chicago Convention, June 10, 1927.

[2] Of Metcalf & Eddy, Engineers, Statler Building, Boston, Mass.

of casing. There does not appear to be any practical scheme of caring for salt water from isolated wells, except the customary salt water ponds which are, at best, a makeshift arrangement. It is reported that a company in Oklahoma is contemplating the evaporation of the salt water from oil wells for the production of sodium chloride and calcium chloride on a commercial basis.

The legislature of Kansas recently passed an Act authorizing the State Board of Health to prevent stream pollution detrimental to the aquatic life of the State. Ernest Boyce, Engineer of the Kansas State Board of Health, points out that this Act gives the Board of Health authority with regard to salt water pollution, including the carrying on of investigational work, because such pollution may easily be detrimental to aquatic life. He states that the Attorney General is now planning a conference of representative oil producers and geologists to discuss ways and means whereby oil may be obtained from the ground without the volume of salt water that is being pumped at the present time.

Pollution from oil refineries. In the case of oil refineries, the principal effect on water supplies has been due to the wash water from the agitators in which the crude gasoline and kerosene are purified. These wastes contain taste and odor-producing substances and interfere with purification processes. Aeration in addition to coagulation and filtration has proven very beneficial, but is not a complete remedy if the extent of pollution is too great. In such cases, more complete removal of the taste-producing substances at the source is essential.

F. M. Veatch states that the most practicable method thus far devised for controlling pollution of water supplies by refinery wastes is ponding of the wastes and discharge only at high river stages. Ernest Boyce, Engineer of the Kansas State Board of Health, has furnished the following information in regard to the method of handling the wastes from the refinery of the Standard Oil Company of Kansas at its Neodesha plant:

> The company has provided large impounding reservoirs which will hold 90 days' flow of wastes from the refinery, and in this manner protects the water supplies of Independence, Coffeyville and Cherryvale. These reservoirs cover about 15 acres and are about 12 feet deep. A daily record is made of the operation of these reservoirs, which is filed monthly with this department. Liaison is maintained between the refinery and the Water Superintendent at Independence, the agreement being that no refinery waste will be discharged without the consent of the Water Superintendent, which is not given unless he is convinced that the river is at a stage which will permit sufficient dilution to avoid complaint from taste.

SOURCES OF OIL POLLUTION

There are various causes of oil pollution of waters, practically all of which are potential sources of injury to water supplies. The United States Bureau of Mines after extensive field investigations of coast waters reported the following sources of oil pollution (2):

Oil-burning and oil cargo vessels
Ship repair yards
Oil terminals and refineries
Oil fields
Gas plants
Other industrial plants
Sewers

Oil-burning and oil cargo vessels. It was concluded that a very large proportion of the oil pollution was due to oil-burning and oil cargo vessels resulting from the pumping out of oil-contaminated ballast water and bilge water, cleaning and flushing operations including sludge from oil storage tanks or compartments, and accidents including stranding, collision and sinking. Ballast water was considered the principal source. Even when the oil is discharged long distances outside the 3-mile limit, it may be carried into territorial waters by winds, tides and currents. Oil-burning vessels which now comprise half of the total power shipping carry such enormous quantities of oil, either as fuel or as cargo, that even though the losses are only a small fraction of the total quantity carried, they are of considerable importance from the standpoint of oil pollution.

Ship repair yards. In the case of ship repair yards, more or less waste oil gets into adjacent waters at times, even where efforts are made to prevent it. If the bottom plates are to be removed or if the damage has been so great as to prevent the cleaning of the oil tanks before the vessel is raised on the dry-dock, large quantities of oil wastes escape into the water. Because of the lack of adequate means for preventing the escape of oil or of recovering it from the water, this was considered one of the important sources of pollution of waters.

Refineries and oil terminals. Oil pollution from refineries may be caused by leakage from stills, pipe lines, filling-racks, draining of tanks and spills in the yards. Most of the large refineries were found to have complete drainage systems and efficient separators for recovering the oil, although some of these separators were inefficiently operated. Other refineries, particularly some of the smaller ones, were not ade-

quately equipped for recovering the lost oil and constituted a continuous source of pollution which was especially bad during heavy rains when oil spilled in the yard was washed into nearby streams.

Some oil is lost in unloading and loading operations at the docks in spite of precautions and, in the absence of adequate floating booms and suitable skimming facilities, may result in considerable pollution. This statement applies also to oil-terminals and oil-distributing stations which handle very large quantities of oil.

It was concluded that, under the existing conditions, oil refineries and oil-terminals constituted one of the important sources of oil pollution on the Atlantic and Gulf coasts.

Oil fields. Pollution of water supplies by oil field operations has already been referred to. Investigations by the Bureau of Mines led to the conclusion that oil fields are of minor importance as a general source of oil pollution.

Gas plants. In the manufacture of carburetted water gas, considerable quantities of tar or heavy oil are formed and pass away as water mixtures. In spite of the fact that the majority of plants visited were making an effort to remove the tar by means of a series of gravity type separators, it was concluded that, under existing conditions, gas works constitute an important source of oil pollution, although such pollution is usually local in its effects.

Other industrial plants. Power houses and industrial plants in general using oil as fuel may become sources of oil pollution due to improper handling and storage of the oil. Railroad yards and round houses where the railroads use oil for fuel may be sources of serious oil pollution. Such plants are a minor source of general oil pollution and by the use of available methods and devices, this source can be practically eliminated.

Sewers. Although the discharge from sewers was not a major source of oil pollution, serious trouble from this source has been experienced at times in some localities. Unless some consistent policy is maintained for handling waste oil from private and public garages and industrial plants connected with sewers, this may become an important source of oil pollution.

EFFECTS OF OIL POLLUTION

Aside from its effect on water supplies previously referred to, oil pollution of waters has a number of deleterious effects, including the following, which are discussed in the report of the Interdepartmental Committee on Oil Pollution (2, Appendix 3, pp. 25, 50–59):

Damage to bathing beaches and shore property
Destruction of aquatic life
Increasing fire hazard to shore structures and floating craft
Injurious effects on public health

Bathing beaches and shore property. The presence of oil on beaches and other shore waters used for recreational purposes renders them unattractive and unfit for bathing. The oil is not only objectionable on the body and difficult to remove therefrom, but is injurious to bathing suits and if carried into houses, damages floors, floor coverings and clothing. It also causes fouling of pleasure craft.

Oil pollution at seaside resorts naturally tends to depreciate the value of the property. Much information in regard to oil pollution at bathing beaches in 1921–1922 is given in a report by F. W. Lane, Petroleum Chemist of the United States Bureau of Mines, A. D. Bauer, Associate Petroleum Chemist of the Bureau of Mines, H. F. Fisher, Mechanical Engineer representing the American Petroleum Institute and P. N. Harding, Mechanical Engineer representing the American Steamship Owners Association (3). It was concluded that some action is necessary to ensure the maintenance of beaches in satisfactory condition for use.

Aquatic life. Fish may be trapped in bodies of water covered with oil and eventually suffocated, but the chief trouble in the fishing industry is the injurious effects of the oil on spawning grounds and on the minute plant and animal food supply in the water, which cause the fish to migrate.

Shellfish in the larval stage, swimming about just beneath the surface of the water, are destroyed by the presence of an oil film. Oil slime on the bottom undoubtedly has an injurious effect on the setting of the oysters. Experiments indicated that oil pollution unless very severe will not kill adult shellfish, but will render them unfit for food.

Danger to Fisheries from Oil and Tar Pollution of Waters is the subject of a report by J. S. Gutsell, Scientific Assistant of the United States Bureau of Fisheries (4).

Water-fowl coming in contact with heavy oil and tarry substances get their feathers matted together, disabling them and causing them to perish from hunger and exposure. This condition has caused extensive destruction of aquatic bird life.

Fire hazard. Oil pollution increases the fire hazard to shore structures and floating craft. When crude oil is freshly spilled in water,

there is danger of direct ignition due to the presence of readily volatile substances, such as gasoline and kerosene, but the fire hazard from oil pollution is due very largely to the danger of propagating fires started from other sources.

The control of oil pollution in Massachusetts waters is vested in the Department of Public Safety and Regulations have been prescribed by the Fire Marshal. These Regulations refer to the discharge of "crude petroleum or its products or any other inflammable oil, or any bilge water. . . . ." According to information received from Mr. Evans, who has direct charge of oil pollution control, cases have recently been brought against two oil refining companies for violation of the law. In one case, the company was found guilty, but has appealed. In the other case, the company was found not guilty, because it was proven that the oil complained of was not "crude petroleum" and was not "inflammable."

Public health. Oil pollution is detrimental to public health principally because it discourages healthful water and shore recreation. The Effect of Oil Pollution of Coast and Other Waters on the Public Health is the subject of a report prepared by F. W. Lane and A. D. Bauer of the United States Bureau of Mines, H. F. Fisher representing the American Petroleum Institute and P. N. Harding representing the American Steamship Owners Association (5).

MEANS OF PREVENTION OF OIL POLLUTION

Investigations by United States Bureau of Standards. The character of oil-water mixtures and devices for removing the oil were investigated by the Bureau of Standards (2, Appendix 5, pp. 76–84). Among the conclusions were the following:

> From 95 to 99 per cent of the fuel oil in such (ballast water) mixtures may be termed floating oil, i.e., it will normally rise to the surface of a free water mixture within 60 to 120 seconds.
>
> From 1 to 5 per cent of the fuel oil in such mixtures may be termed suspended oil, i.e., it may require from 2 to 4 hours settling before it clears the free water.
>
> A small fraction of 1 per cent of the fuel oil in such mixtures may be termed emulsified oil, i.e., it may require several days or weeks' settling before it clears the free water.
>
> No great difficulties are usually encountered in the removal of floating oil from ballast water mixtures by comparatively simple gravity separators.
>
> No gravity separator of a size suitable for use on shipboard can be expected to remove suspended or emulsified oil.

The recommendations were as follows:

1. That gravity-type separators be recognized as suitable for the separation of oil from ballast water on shipboard in non-territorial waters.

2. That separators which, during thorough test at sea under average operating conditions, can show an effluent averaging not more than 0.01 of 1 per cent oil, be approved for such use provided they are equipped with either (*a*) satisfactory automatic control; or (*b*) manual control whereby the operator may determine the character of influent and effluents constantly, and control the rate of flow through the separator instantly without leaving his station.

Investigations of Bureau of Mines. The Bureau of Mines in cooperation with the American Petroleum Institute and the American Steamship Owners Association has made an investigation of available methods and devices for handling oil-contaminated water and has recently issued a publication on the subject (6).

The methods considered include those designed to dispose of oil-contaminated water and other oil wastes by the use of facilities provided on land or in port and those designed for use on ships. With respect to the former, the following statement is made:

Of the three methods for disposing of oil wastes from ships by means of facilities provided in port, petroleum harbors seem impractical because of delays to shipping and the consequent decrease in earnings, and bilge-water pumping stations seem impractical in large ports because of the enormous cost of installation. The use of collecting barges appears to be the only feasible and practical method for all ports.

The barge method was carefully studied as applied to the port of New York and it was estimated that the initial investment required to take care of all the oil-contaminated water that would have to be handled in the harbor would be approximately $900,000 and that the net annual expense would be about $255,000, corresponding to a total cost of about $70 per vessel per call.

With respect to the methods for use on the ships, it is stated that "gravity" separating devices appear to be the most promising. Descriptions and illustrations of different types are given. It is believed that bilge water being correspondingly small in volume can be treated by means of a small pump and flexible hose suction discharging into a separating tank from which the oil is skimmed at intervals and returned to the fuel storage tank and the water drained back into the bilge.

So far as oil-burning ships are concerned, it is believed that the most satisfactory ultimate solution will involve the use of a separat-

ing device on each individual ship and facilities in harbors for collection and proper disposal of heavy sludge and other oily wastes that the separator will not handle. If a completely successful device for separating oil from ballast water on general cargo vessels cannot be readily developed and applied, one that would satisfactorily reduce the bulk of the oil-water mixture to a large extent would greatly facilitate subsequent collection by barges which will presumably be required in any case to dispose properly of tank sludge and other oily refuse.

Methods and devices for separating oil from wastes discharged by ship-yards, oil refineries and gas plants were considered and the following conclusion was reached (6, p. 66):

> It is believed that the apparatus now available for handling oil-water wastes from land plants are adequate, when properly installed and used, largely to eliminate oil pollution from such establishments—with the possible exception of ship-repair yards, where the normal conditions of operation are such that the control and proper disposal of oil refuse and oil wastes are very difficult. Ship-repair yards will require the further development of means for coping effectively with this situation.

Control of oil pollution in Rhode Island. Even though adequate means be provided for preventing oil pollution, proper operation and inspection are necessary to secure satisfactory results. An excellent example of the control of oil pollution is furnished by the State of Rhode Island (7). Through adequate laws, strict rules and regulations and coöperation with parties causing pollution, serious oil pollution conditions were brought under control.

In the great majority of cases, spills on shore at the oil companies in Rhode Island are now prevented from reaching the public waters by dikes, lead-back drains and similar protective measures.

Under the legislation established by the Board of Purification of Waters, pumping out bilge water or water ballast from oil tankers is absolutely prohibited in Rhode Island waters. It is now the custom for all oil tankers while loading or unloading to display a red flag by day or a red lantern by night as a caution signal to passing shipping. All steamship companies operating in Rhode Island waters have been officially requested by the Board to instruct their Captains to proceed at slow speed while passing oil tankers displaying this signal.

On the unloading dock, all the oil companies have now installed a tight section with a raised edge or rail 6 inches or more in height to catch any oil which may be spilled at the point where the unloading

hose comes over the side of the vessel and connects with the shore pipes lines. The oil companies have also installed a drip pan or sand box to catch the oil which runs out when the hose is disconnected.

All waste waters from oil distillation and refining plants must be passed through properly designed separators. In some separators, the final effluent is passed through some form of filter to remove semi-emulsified oil which will not separate by gravity. Sand has been used, but coke or fine cinders is better. Mr. Gage considers an excelsior mat most advantageous because this can readily be removed and burned.

To reduce the fire hazard, storage tanks are usually located in a pit or surrounded by an embankment or wall to retain the oil in case of an accident or collapse of the tank. This provision also serves as a safeguard against oil pollution. Pipe lines running along the docks or on the water fronts are usually carried in a box filled with sand or sawdust or in a cement-lined conduit draining to a pit or slop tank where any oil leakage may be collected and recovered.

The car-loading yards require considerable supervision to prevent oil spills. The Board insists that all direct drainage connections from car-loading yards into the harbor be removed or effectually sealed. Most of the oil companies now keep the surface of the ground in the loading yard well sanded to absorb minor drips and spills. The oil-soaked sand is scraped off and carted away. Instead of being discharged between the tracks or run into the harbor, the oil sludge and drainage from the tank cars are now discharged into cans or into suitable slop tanks placed beneath the tracks.

Education is considered one of the most important factors in preventing oil pollution.

In a recent letter, the Clerk of the Board of Purification of Waters states as follows:

> We believe that the constant inspection and supervision carried on through agents of the Board is indispensable to keep up the regular and careful use of preventative measures. We believe that emphasis must be continued upon the adoption of safety measures by plants using fuel oil. Escape of such oil is rarely expected yet an accidental discharge will usually readily find its way into the public waters through the drainage system unless some preventative measure has been adopted in anticipation. The Board of Purification of Waters is continuing its survey of such plants and making from time to time suggestions for installation of methods to prevent accidental discharges of oil escaping into the public waters. It is planned shortly to prepare a circular for distribution among manufacturers generally in Rhode Island, calling

attention to methods which have been suggested and adopted at other plants to prevent accidental escape of oil.

CONFERENCES AND LEGISLATION ON OIL POLLUTION

The War Department has jurisdiction over stream pollution from the point of view of navigation, under the River and Harbor Act approved March 3, 1899, and other acts amendatory or supplemental thereto, but no specific mention is made of pollution by oil or oil wastes, which had not become an important question when the legislation was enacted.

Provision for Control of Pollution in New York Harbor. In addition to the River and Harbor Act of 1899 is the Act of June 29, 1888, amended by the Act of August 18, 1894, for the prevention of pollution in New York Harbor. This Act deals with pollution not only by the waste matters referred to in the general act of 1899, but also with respect to oil and oil wastes. Under this Act the supervision of New York Harbor is placed in the hands of the Supervisor of the Port of New York and a naval officer is detailed for this particular work, and the expenses of supervision are covered by special Congressional appropriations.

Joint Resolution of Congress for International Conference on Oil Pollution. Several bills relating to oil pollution were introduced in Congress in the fall of 1921 and referred to the Committee on Rivers and Harbors which held hearings (8) at which representatives of a number of civic associations, Federal and state departments and other interested parties testified. It was brought out that the problem could not be completely solved without international agreement. The outcome was a Joint Resolution of Congress, approved July 1, 1922 (9) requesting the President to call a conference of maritime nations, with a view to the adoption of effective means for the prevention of pollution of navigable waters by oil-burning and oil-carrying steamers, by the dumping into such waters of oil waste, fuel oil, oil sludge, oil slop, tar residue and water ballast.

This resolution was referred by the President to the Secretary of State and an interdepartmental committee was formed consisting of representatives of the following departments:

State Department
Treasury Department
War Department
Navy Department

Interior Department.
Department of Agriculture
Department of Commerce
Shipping Board.

These departments undertook investigations of different phases of the oil pollution problem, including extent of pollution, causes, effects and remedies. The report of the Interdepartmental Committee will be referred to later.

Atlantic City Conference on Oil Pollution. A conference on oil pollution called by the League of Atlantic Seaboard Municipalities was held at Atlantic City August 10 and 11, 1922. This conference was attended by about 75 delegates including Federal, state and municipal officials, representatives of civic associations and others. Much information was presented in regard to the extent of oil pollution, its causes, effects and the possible remedies. Resolutions were passed, endorsing certain bills before Congress. The Conference resolved itself into a permanent organization under the name of the National Coast Anti-Pollution League, and David M. Neuberger, Esq., was elected President.

National Coast Anti-Pollution League. A second meeting of the National Coast Anti-Pollution League was held at Atlantic City, New Jersey, October 1, 2 and 3, 1923, with an attendance of about 135, including Federal, state and municipal officials, representatives of chambers of commerce, oil companies, steamship companies and oyster growers, and others (10). Round table meetings of different groups were held in addition to the general sessions. Resolutions were adopted favoring certain Federal legislation and recommending state legislation including the formation of state sanitary and economic water boards, to have control of water resources.

Oil Pollution Act of 1924. Several bills relating to oil pollution were introduced in Congress in 1923. A hearing on three of these was held before a subcommittee of the Committee on Commerce of the United States Senate (11), at which oral statements were made by a considerable number of interested parties and many written communications received. Most of the pollution bills were referred to the Committee on Rivers and Harbors, which held extensive hearings (12). The outcome was the so-called oil pollution act of 1924, which became law on June 7, 1924 (13).

This Act provides that, except in certain cases of accident or emergency or as permitted by regulations which the Secretary of War is

authorized to prescribe, it shall be unlawful to discharge oil into or upon the coastal navigable waters of the United States from any oil-burning or oil-transporting vessel.

The penalty for violation of the Act is a fine not exceeding $2500 nor less than $500 or by imprisonment not exceeding one year nor less than 30 days, or by both such fine and imprisonment, for each offense. Clearance of such vessels from a port of the United States may be withheld until the penalty is paid, and said penalty shall constitute a lien on the vessel. Provision is also made for revoking the license of the officer of the vessel.

For the administration of the Act the Secretary of War is authorized to make use of the organization, equipment and agencies employed in the improvement of rivers and harbors and the officers and agents in charge of such improvements and the assistant engineers and inspectors employed by them; and the officers of the Customs and Coast Guard Service are charged with the arrest of violators of the provisions of the Act.

Section 9 of the Act also authorized and directed the Secretary of War to make an investigation to determine what polluting substances are endangering or interfering with navigation or commerce upon navigable waters or the fisheries therein, and to report the results of his investigation to Congress within two years, together with such recommendations for remedial legislation as he deems advisable. For this investigation, the sum of $50,000 was authorized in addition to funds already appropriated for river and harbor examinations, surveys and contingencies, which may be drawn upon.

Report of War Department on Pollution Affecting Navigation or Commerce on Navigable Waters. The report of the investigation of pollution of navigable waters, made by the War Department in compliance with the Oil Pollution Act of 1924, was presented to Congress on June 4, 1926 (14).

In addition to domestic sewage the report lists the following industries as the sources of the more injurious polluting substances:

a. Oil
b. Coal mining washery wastes and acid mine drainage
c. Coal distillation
d. Metal trades—pickling, cleaning and plating wastes
e. Pulp and paper mills
f. Tanneries
g. Textile industries—washing, bleaching and dyeing wastes
h. Miscellaneous including distilleries, storage battery service stations, rubber reclaiming, canning factories, creameries and chemical plants

These sources of pollution are discussed and the effects on navigation or commerce and on fisheries are described. A table is given, showing the navigable waters affected by pollution, the principal sources of the pollution and the injurious effects. A summary of the findings is included, and the existing Federal laws relating to the pollution of navigable waters are summarized and data given with respect to state control of pollution. The report states that industries are coöperating with local authorities in a study of the problem and devising methods by which injurious substances in the wastes can be recovered or rendered less harmful before discharge into the waterways. It is stated that industries engaged in the production, storage and transportation of oil are installing more efficient recovery devices and are more zealous in their efforts to prevent the escape of oils into waters by accident or otherwise.

No Federal legislation is recommended at this time, with respect to pollution in general, nor in regard to acid mine drainage in particular. With respect to oil pollution it is recommended (14, p. 28):

> . . . . that the oil pollution act of 1924 be made applicable to the discharge of oil from any source, into or upon the coastal navigable waters of the United States, or into or upon any of the Great Lakes, their harbors and their connecting channels.

Present Status of Oil Pollution Legislation. The Oil Pollution Act of 1924 applies only to oil-burning and oil-carrying vessels. Several bills extending the Federal jurisdiction to land sources were introduced in the last Congress and referred to the Committee on Rivers and Harbors, but no action was taken on them. Presumably similar bills will be introduced in the next Congress and unless oil pollution from land sources is reduced to negligible amounts it is probable that further legislation will be enacted.

Report of Interdepartmental Committee on Oil Pollution of Navigable Waters. The Interdepartmental Committee formed as a result of the joint resolution of Congress calling for a conference of maritime nations on oil pollution, made its report to the Secretary of State on March 13, 1926 (2). This report deals with the following general subjects:

I. Authority and organization of the Committee
II. Description of the construction work and investigations made at its instance by departments and agencies of the Government
III. Description of steps taken by the United States, to deal with the problem

IV. State measures taken to deal with the problem in foreign countries
V. Summary: conclusions and recommendations.

The report also contains the following appendices:

1. Joint resolution of Congress, 1922
2. Oil pollution act of 1924
3. General report of the Bureau of Mines on pollution by oil, of the coast waters of the United States
4. Report of the Bureau of Mines, entitled "The Action of Sea Water on Fuel Oil"
5. Preliminary report of the Bureau of Standards, on the Character of Oil-Water Mixtures occurring on shipboard, and the investigation of devices designed for the removal of oil from such mixtures
6. Report of Bureau of Fisheries: Preliminary Investigation of the Effect of Oil Pollution on Marine Pelagic Eggs
7. Report of the United States Shipping Board
8. Report of the Department of State on the problem, and efforts to deal with it in foreign countries

It is not within the province of this paper adequately to abstract this report, but it is commended to all who are interested in the subject of oil pollution.

International Conference on Oil Pollution. After the Interdepartmental Committee had made its report, a conference of maritime nations was called, in accordance with the Joint Resolution of Congress, previously referred to. This conference was held at Washington June 8–16. 1926. In addition to the United States, delegates were present from the following 12 nations: Belgium, British Empire including Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain and Sweden.

Senator Frelinghuysen was elected Chairman. Committees were formed, to consider the following matters:

Facts and causes
Classification
Zones and enforcement
Admeasurement
Drafting
Technical

The minutes of the meetings have been published in English and in French in a United States Government document (15).

It was agreed that the report of the American Interdepartmental Committee formed, in the main, a sound basis for the work of the

Conference. The Conference reached an agreement on the following recommendations to the respective governments, for adoption by international agreement (15, pp. 438–442).

(1) That the Governments concerned provide for a system of prescribed areas in waters off their coasts beyond territorial limits (if necessary, after consultation with neighboring governments) within which vessels of the classes mentioned in recommendation No. 4 shall not discharge crude, fuel or diesel oil or mixtures having an oil content greater than that stated in recommendation No. 5.

(2) That along coasts bordering the open sea, such areas shall not extend more than 50 nautical miles from the coast, except, that if such extent is in particular instances found insufficient because of the peculiar configuration of the coast line or other special conditions, the Government affected may extend its area to a width of not exceeding 150 nautical miles, after consultation with neighboring governments, if necessary.

(3) That due notice of the establishment of any areas shall be given to the governments concerned in the form of marked charts or otherwise.

(4) That the regulations adopted with respect to prescribed areas shall be applicable to all seagoing vessels other than war vessels, carrying crude, fuel or diesel oil, in bulk as cargo or as fuel for boilers or engines, due consideration being given to the special necessities of small vessels. It is assumed that the naval authorities of each country will take the necessary measures to ensure that vessels classed as war vessels shall take every possible precaution to prevent oil pollution.

(5) That the discharge of oil or oily mixtures be prohibited within such areas if the oil content exceeds 0.05 of one per cent, that is, if it is sufficient to constitute a film on the surface of the sea visible to the naked eye in daylight in clear weather.

(6) That each government agrees to use all reasonable means to require its vessels to respect all such areas.

(7) That no penalty or disability of any kind whatever in the matter of tonnage measurement or payment of dues be incurred by any vessel by reason only of the fitting or any device or apparatus for separating oil from water.

(8) That dues based on tonnage shall not be charged in respect of any space rendered unavailable for cargo by the installation of any device or apparatus for separating oil from water.

(9) That the term "device or apparatus for separating oil from water" as used in recommendations Nos. 7 and 8 shall include any tank or tanks of reasonable size, used exclusively for receiving waste oil recovered from the device or apparatus, and also the piping and fittings necessary for its operation.

(10) That each government should carefully observe the operation and effect of the area system off its coasts, and exchange information thereon with the other interested governments, so that if, after reasonable experience, any government may consider that such areas do not sufficiently protect its coasts, or that pollution beyond such areas has become or threatens to become a menace, such government may be in position to raise with the other governments

the question whether the discharge beyond the limit of such areas of oil or oily mixtures constituting a nuisance should be prohibited.

(11) That a central agency be established as soon as practicable for receiving, coördinating, and circulating to the governments concerned information of interest relating to the system of areas, the establishment of which is suggested in the foregoing recommendations, the experience with that system and other data deemed advisable.

A Draft of Convention was adopted, for the consideration of the respective governments, to take effect as soon as the ratification of five of the governments represented at the Washington conference of June 1926, shall have been notified to the Government of the United States.

The writer has been in communication with the Secretary of State and has been advised that it is expected that this Government will shortly take steps to ascertain from the governments whose representatives attended the Preliminary Conference, their views with regard to the Draft of Convention, and upon receipt of these views it is hoped that steps may be taken looking to the adherence by the interested governments to an agreement substantially in the form of the Draft of Convention. Various shipping interests and other interested organizations in the United States and in Great Britain have agreed that the recommendations of the preliminary conference should be voluntarily put into operation.

PRESENT STATUS OF OIL POLLUTION

Information from Kenneth Allen, regarding Conditions in New York Harbor. In a recent letter Kenneth Allen, Sanitary Engineer of the City of New York, Board of Estimate and Apportionment, states that conditions in New York Harbor have continued to improve during the past two or three years. This he believes is due in part to the general publicity given the matter and the more general realization of the damage that was being done, and in part to increased vigilance by the Supervisor of Harbor.

There are occasional complaints at bathing beaches in the summer, but much fewer than formerly. The Harbor Supervisor, Capt. K. M. Bennett, U.S.N., stated that oil and gas companies, shipyards and those engaged in cleaning oil tanks or vessels are all more careful to prevent spills than they were. Nevertheless, there are still temporary conditions when much oil either as scum or more often sleek, is in evidence in the lower East River and Upper Bay, especially

along the Brooklyn shore and in the Kill von Kull. The small tributaries, Newtown Creek and Gowanus Canal in Brooklyn, are still liable to heavy oil pollution from industries along their shores.

Report of New York Joint Legislative Committee. The report of the Joint Legislative Committee in reference to the Pollution of Waters of the State of New York, dated February 28, 1927, states that in 1923 conditions at all the beaches near New York were very bad, but that a great improvement is noticeable at the present time, although much still remains to be done. The Committee makes the following recommendations:

1. Strict enforcement of the Oil Pollution Act and Harbor Rules and Regulations.
2. Policing the Harbor must be more thorough, which can only be brought about by the addition of more patrol boats properly manned and of a modern type.
3. The extension of the "Oil Pollution Act" and the entering by the United States into an international agreement with other maritime nations to prohibit the dumping of oil, oil laden bilge, garbage and refuse at sea within prescribed areas sufficiently removed from the coast to prevent such from reaching our beaches.

Information from President of National Anti-Pollution and Conservation League. David W. Neuberger, Esq., President of the National Anti-Pollution and Conservation League (formerly National Coast Anti-Pollution League), in a recent letter states that the League is still active in the matter of elimination of oil pollution of waters and at the present time is conducting a radio campaign against pollution, over WGL, New York City. His opinion is that pollution of the coastal waters has not and will not be eradicated without prohibition against land plants.

CONCLUSION

It is generally reported that oil pollution conditions have improved decidedly in recent years, due to the arousing of public opinion, agitation of the subject, legislation, coöperation, education and other causes, although conditions in many places are still far from satisfactory. The indications are, however, that the oil pollution problem is well on the way to solution.

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QUANTITATIVE STUDIES OF PHENOLS IN WATER SUPPLY[1]

By Wellington Donaldson[2] and R. W. Furman[3]

The Water Department of the City of Toledo had a comprehensive survey made of its water resources in 1925 and 1926 in order to define policies to be adopted in future extensions or developments of its public water supply. This survey reviewed not only the limitations of the present supply taken from the Maumee River at a point near the upper or southerly end of the city, but investigated as well the probable quality, quantity and cost of a supply to be developed from the upper river, and the probable quality and cost of a supply to be developed from an intake in Lake Erie. In connection with the studies of water quality an extensive sampling program was carried out, as follows:

a. Collection thrice weekly by motor boat or tug from the lower stretch of the Maumee River opposite and below the water works intake out as far as the harbor light, at the outer edge of Maumee Bay.

b. Collection thrice weekly by tug during the navigable season from Lake Erie 5 miles S.E. of the harbor entrance at suggested intake sites. During the winter, a few samples were collected off-shore through the ice at these points.

c. Collection from regular day steamers of a series of samples from Lake Erie from the mouth of the Detroit River to the entrance of Maumee Bay.

d. Collection weekly or oftener from the Maumee and Lake Erie Canal and the Maumee River above the Toledo intake at various points up to and including the Defiance intake, also the Auglaize and Tiffin Rivers near Defiance, the Blanchard and Ottawa Rivers near Kalida, Ohio.

e. Collection, occasionally, during the beet sugar season, from the Blanchard River at Ottawa, at the Putnam-Hancock counties line and at Findlay.

f. Collection at least twice of industrial wastes discharging into the lower Maumee, Ten-Mile, Otter and Duck Creeks.

The special samples, some 3600 in number, covering a period from September 3, 1926, to June 21, 1927, were handled in the Toledo

[1] Presented before the Water Purification Division, Chicago Convention, June 10, 1927.

[2] With Fuller and McClintock, Engineers, New York, N. Y.

[3] Superintendent of Filtration, Toledo, Ohio.

filtration plant laboratory by the regular staff, with the exception of a series of special tests carried out on the ground by the chemist of the Defiance waterworks. The main purpose of the laboratory studies was to determine by the usual physical, chemical and bacterial tests the relative suitability of the waters examined for water supply purposes. Incidental, however, to the main objective, certain studies were carried out on phenols to learn if possible the relative amounts present and their probable effect. This paper will not attempt to deal with the main phases of the water survey as outlined above, but will be confined to the local experience with detecting and estimating phenols in a total of 556 samples from different sources. Whatever conclusions may be drawn from the data, it is hoped that the results may be useful to other waterworks chemists who may have to deal with similar problems.

EARLIER DETERMINATIONS OF PHENOLS

The effects of phenols from coal tar wastes or the wastes of other destructive distillation processes upon water supply are well recognized and need not be discussed here. In the various studies which have been conducted elsewhere on phenol pollution of water supplies there has been a conspicuous absence of quantitative data as to the amount of phenol encountered. In fact most investigators have concluded that the amounts of phenol causing taste and odor after chlorination were too small to be evaluated quantitatively by chemical tests, or else the tests themselves were not considered sufficiently specific or dependable to be useful.

In connection with studies of the Youngstown, Ohio, water supply, Van Arnum (1) reported certain numerical data on the raw and filtered water, using the Folin-Denis reagent after distillation. His results, which are not stated in parts per million, simply indicate observed variations in a series of 24 tests of the raw and filtered water. Unfortunately, the results are vitiated by the finding in the heavily polluted Mahoning River of other substances than phenols, such as hydrogen sulfide from slag, which gave similar color responses.

The results of Toronto studies, reported by Howard (2) comprise, so far as the writers are aware, the only definite published figures as to quantitative findings of phenol in a water supply. An unstated number of daily tests using the Folin-Denis method showed a maximum of 12 parts per billion (0.012 p.p.m.) in the raw water when polluted with industrial wastes, while the average figures for

two months were 1.73 and 2.1 parts per billion (0.00173 and 0.0021 p.p.m.) The filtration plants reduced the phenol content as shown by the tests about 50 per cent. Iodoform taste was noted in the filtered water showing a phenol content of 6 parts per billion (0.006 p.p.m.), after the application of 0.2 p.p.m. chlorine.

Howard in a later paper with Thompson (3) indicates misgivings as to the accuracy of the figures just quoted, by stating: "The determination of phenols in raw water by the distillation method was carried out for two years and actually showed a slight increase during susceptible taste periods, but we have not found the test sufficiently sensitive to use as an index to phenol pollution." They further state: "The estimation of small amounts of phenol in water is difficult and the results so unreliable that we have been compelled to confine our observations to actual taste-tests which have seldom failed." These conclusions evidently are applicable to the Fox and Gauge method, as well as to the Folin-Denis method upon which the earlier quantitative data were based.

The estimation of phenols in the great dilution in which they are capable of affecting water supplies after being chlorinated is admittedly a difficult and uncertain undertaking at the present time. This is necessarily so when one remembers that the term "phenols" is a very inclusive one, embodying a great variety of aromatic ring compounds containing one or more hydroxyl groups. Of the complex mixtures represented by polluted waters we know little except that coal distillation and similar wastes are the most prolific and potent sources of trouble to water supplies. Of the effect of sewage or other unstable organic wastes, little is known, although phenols have been demonstrated as being among the metabolic products of the animal body.

We do not intend to enter here into a discussion of the various tests which have been proposed for the detection and estimation of phenols. A comprehensive and able review of the subject has recently been made by Gibbs of the United States Hygienic Laboratory (4), who classifies the hundred or more tests found in the literature. It is hoped that the Public Health Service will carry out additional studies on this important subject so as to give much needed confirmatory data as to the merits of the several tests.

TOLEDO DETERMINATIONS OF PHENOLS

For purposes of the Toledo Water Survey, odor and taste tests were not considered except for confirmation, although their superior sensitivity is recognized. A large number of samples from various sources, had to be tested daily, some unpolluted and others known to contain appreciable amounts of phenol. A simple measuring stick was desirable by which the relative amounts of phenol could be stated and known phenol pollution traced from its point of origin.

Preliminary to the quantitative work on water samples the sensitivity of four of the better known reagents to various common phenols was tried, with results as shown in table 1.

Bromine gives an opalescence or white precipitate according to amount present; Millons gives a pink to red color; Folin-Denis gives

TABLE 1

Minimum concentration of various phenols in distilled water required to give a visible reaction in a standard 50 cc. Nessler tube

Parts per million

SUBSTANCE	BROMINE	MILLON'S REAGENT	FOLIN-DENIS REAGENT	FOX AND GAUGE REAGENT
Phenol (C_6H_5OH)	26	0.2	0.02	0.01
o-Cresol	50	1.5	0.02	0.01
m-Cresol	15	0.3	0.02	0.01
p-Cresol	150	0.3	0.02	0.01
Cresylic acid mixture (35:40:25)	25	0.7	0.02	0.02
Wood creosote	80	2.0	0.02	0.02

a blue or green color; while Fox and Gauge gives a yellow to orange color.

The Fox and Gauge reagent, on account of its greater sensitivity, indicated above, and its comparative freedom from interference by other substances than phenols, was made the basis of the quantitative data herein reported. The Fox and Gauge method for tar acids originally described in the Journal of Chemical Industry (39:260 T) was used with certain modifications suggested by Furman and Kruger (in publication), as follows:

Reagents

1. Recrystallized sulfanilic acid, 1.91 grams in 250 cc. water.
2. Pure sodium nitrite, 0.85 gram in 250 cc. water.

3. Sulphuric acid, 1 part strong acid and 3 parts water.

4. Sodium hydroxide, 8 per cent solution.

5. Stock solution pure phenol, 10 grams in 1000 cc. water (standardized against bromine), 1 cc. = 10 mgm.

6. Standard solution pure phenol, 1 cc. stock solution in 1000 cc. water (freshly prepared), 1 cc. = 0.01 mgm.

7. Potassium platinic chloride, 2 grams in 100 cc. con. hydrochloric acid diluted to 1000 cc. water.

Procedure

Distil 250 cc. of the samples and collect three successive 50 cc. Nessler tubes of the distillate. To each distillate add 2.5 cc. diazotized sulfanilic acid (freshly prepared by mixing 5 volumes of sulfanilic acid solution with 1 volume sulfuric acid, adding 5 volumes sodium nitrite solution and packing in ice) and 2.5 cc. sodium hydroxide solution. Match colors at the end of exactly five minutes against permanent standards prepared by diluting platinum solution to 50 cc. as follows:

PHENOL EQUIVALENT	PLATINUM SOLUTION
mgm.	*cc.*
0.000	1.5
0.001	2.2
0.003	3.8
0.005	4.5
0.007	5.5
0.010	7.0
0.020	10.0
0.030	17.0

The sum of the milligrams in the three tubes, multiplied by 4, represents the phenols present, expressed as parts per million pure phenol (CH_6O_5H).

In the preliminary studies, the unknown colors were matched against natural standards prepared from pure phenol. Such standards deepen on standing at room temperature and it was found more convenient to use permanent platinum standards, which gave a satisfactory match within the range indicated, although difficulty was experienced in matching higher concentrations or mixtures of cresols. For samples of heavier phenol content, aliquots were taken and made up to 250 cc. with phenol-free water before distillation. Considerable care must be used to guard against contamination of glassware from previous determinations.

No difficulty was experienced in getting blanks except on certain occasions when the tap water in the laboratory from which the distilled water supply was made responded to tests for phenols.

The principal difficulty with the method has been the failure to recover the entire amount of phenols in the first three 50 cc. portions distilled. In trials with known phenols, the first distillate usually contained the bulk, the second distillate a lesser amount and the third still less. In the routine water samples, however, it was not uncommon to recover substantial amounts in the first tube and none in the two following tubes. In a few instances, none was found in the first tube, while the second or third tubes showed measurable

TABLE 2

Recovery expressed in terms of C_6H_5OH

	MILLIGRAMS TAKEN	CONCENTRATION	MILLIGRAMS RECOVERED			
			First tube	Second tube	Third tube	Total
		p.p.m.				
o-Cresol	0.001	0.004	Trace	0	0	Trace
	0.003	0.012	0.001	0	0	0.001
	0.015	0.060	0.007	0.004	0.004	0.015
	0.025	0.100	0.020	0.005	0.003	0.028
m-Cresol	0.015	0.060	0.008	0.004	0.004	0.016
	0.025	0.100	0.010	0.008	0.005	0.023
p-Cresol	0.015	0.060	0.004	0.002	0.001	0.007
	0.025	0.100	0.007	0.006	0.003	0.016
Phenol	0.015	0.060	0.005	0.004	0.004	0.013
	0.020	0.080	0.007	0.005	0.004	0.016
	0.025	0.100	0.010	0.007	0.005	0.022
Cresylic acid mixture (35:40:25 o, m, p, cresols)	0.015	0.060	0.007	0.004	0.002	0.013
	0.025	0.100	0.015	0.005	0.003	0.023

amounts. If the entire phenol content could be dependably concentrated in the first distillate, the sensitivity of the test would be increased over the figures indicated in table 1, making it capable of detecting 2.5 parts per billion (0.0025 p.p.m.) in the case of our routine test, or a smaller amount, if larger portions than 250 cc. be taken for distillation. The actual recovery of known amounts of certain pure phenols is shown in table 2.

From these data it will be noted that, in the case of pure phenol, an average of only 85 per cent was recovered in the three tubes.

Distillation could of course be continued by steam or additions of distilled water until a blank tube was obtained, but the heavy sampling programs made inadvisable such complications or the collection of larger samples. While limitation of the test to the third tube obviously fails to satisfy the requirements of a critical quantitative

TABLE 3

Amount of phenols found in water samples examined, stated in parts per billion (0.001 p.p.m.) C_6H_5OH

SAMPLING POINT	NUMBER OF TESTS	NUMBER OF TIMES PRESENT	PARTS PER BILLION		
			Average	Maximum	Minimum
Maumee River at Toledo Intake	32	16	5.0	20	0
Miami and Erie Canal at Miami	28	13	5.1	52	0
Maumee River at Turkey Foot Rock	38	19	4.6	22	0
Miami and Erie Canal at Napoleon Intake	30	24	6.3	40	0
Auglaize River below Power Company Dam	32	19	5.9	40	0
Tiffin River at Brunersburg	31	17	4.5	24	0
Blanchard River 5 miles N. Kalida	20	15	5.9	16	0
Ottawa River at Kalida	20	16	8.9	72	0
Blanchard River at Ottawa	1	1		8	8
Blanchard River at Putnam-Hancock, line	1	0		0	0
Blanchard River below Findlay	1	1		16	16
Maumee Bay at outer Harbor light	77	29	3.6	52	0
Lake Erie, 5 miles S. E. of Harbor light (3 miles off-shore)	77	30	3.7	32	0
Lake Erie, 5 miles S. E. of Harbor light (5 miles off-shore)	39	18	4.7	24	0
Lake Erie, near mouth Detroit R.	17	9	7.9	52	0
Total	444				

determination, yet this procedure was considered adequate for the local needs. In view of the greater readiness of the phenols to distil over from the water samples, it is fair to assume that the determinations represent better than 90 per cent of the total amount present.

With these limitations stated, the principal findings are shown in table 3.

PHENOLS IN INDUSTRIAL WASTES

In addition to the above results, which represent water actually used or capable of being used as a source of water supply, examination was made of the principal industrial wastes discharging into the water courses in the vicinity of Toledo. Of 20 such wastes sampled at their outlets along the Maumee River waterfront, 37 tests showed a phenol content ranging from 4 to 19,000 parts per billion with an average of 1129 (1.129 p.p.m.).

Of 11 such wastes discharging into Ten-Mile and Swan Creeks, 22 tests gave a range from 4 to 37,800 parts per billion, with an average of 7308 (7.308 p.p.m.)

Of 10 such wastes, discharging into Duck and Otter Creeks, 20 tests gave a range of 0 to 1920 parts per billion, with an average of 149 (0.149 p.p.m.)

The principal contribution of phenol pollution locally is by the coke plant of the Toledo Furnace located at the mouth of the Maumee River. Tar passed from this drain at times. Many of the other trade waste samples had distinct odors of coal tar and some contained phenols in amount sufficient to be studied by confirmatory tests. Practically all of the wastes studied are discharged into the Maumee below the Toledo intake or into Maumee Bay. Except under extraordinary circumstances they would not affect the present water supply, although their bearing on a water supply from Lake Erie would be important.

Regarding conditions on the upper Maumee and its tributaries sources of phenol waste are known to exist, as for instance, at the gas works at Defiance. The consistent showing of phenols in the Tiffin River at Brunersburg has, however, not been satisfactorily explained. No source of phenol pollution is known on this water-shed which is exclusively agricultural, although the possibility of some undiscovered pollution such as from creosote cattle dips has not been excluded by detailed examination of all the tributary streams.

AMOUNT OF PHENOLS CAUSING TASTE

In comparison with the analytical figures given in table 3 it is interesting to note the various statements as to the amount of phenol required to give a taste in chlorinated water.

In the familiar 1919 Milwaukee water works investigation, when attention was first called to the effects of coal tar wastes on chlor-

inated waters, it was stated that 2 parts per billion (0.002 p.p.m.) phenol could be detected in the water supply after sterilization with 0.22 to 0.34 p.p.m. chlorine. A later investigation by the Milwaukee Sewerage Commission indicated that ammonia condensation liquor when added to chlorinated Lake Michigan water in dilutions equivalent to 20 parts per billion (0.020 p.p.m.) of phenol gave taste.

In investigations at the Toronto filtration plant by Howard in 1921–1922 (2) the critical range for chloro-phenol taste and odor in Lake Ontario water was found between 2 and 17 parts per billion (0.002 and 0.017 p.p.m.) phenol with chlorine dosages between 0.175 and 0.40 p.p.m. Chlorine doses lower than 0.10 p.p.m. did not cause taste with phenol, while chlorine doses in excess of 0.65 p.p.m. eliminated the taste present with smaller amount of chlorine. The combination of 7 parts per billion (0.007 p.p.m.) phenol and 0.22 p.p.m. chlorine was particularly bad, both as to taste and odor. Phenol when added in concentrations of 10 to 64 parts per billion (0.010 to 0.064 p.p.m.) to water containing 0.2 p.p.m. chlorine was almost undrinkable due to the "iodoform" taste and odor.

In the Cleveland studies by Ellms, Marshall and Phillips (1) the reliability of the Fox and Gauge test was conceded for "quantities as small as 0.1 p.p.m. of cresols," but it was further remarked, "As a result of our experience with the tests described above (i.e. Folin-Denis and Fox and Gauge), we conclude that none of them is sufficiently sensitive to make them valuable in estimating tar acids in the concentration in which they occur in water supplies, and in which they give rise to objectionable taste and odor when the water is chlorinated." The Cleveland studies used cresylic acid mixture (35:40:25, o, m, p, cresol) as the unit of expression, hence the above statement may be interpreted to mean that the critical amount of phenols, expressed as cresylic acid, lies well below 100 parts per billion (0.10 p.p.m.)

In further report of the extensive Cleveland studies Ellms and Lawrence (6) state that, in distilled water, pure phenol unchlorinated could be detected to a reasonable certainty in concentrations of 40 p.p.m. though not in 20 p.p.m. By the addition of chlorine and boiling to remove excess chlorine the concentration of 200 parts per billion (0.2 p.p.m.) phenol was easily detected.

The sense of taste and smell seems to be more highly developed in England than in this country. Adams reports (5) taste and odor with phenol concentration of 0.5 to 1.0 part per billion (0.0005 to

0.001 p.p.m.) by adding pure phenol to chlorinated well water, one observer being able to detect a concentration of 0.2 part per billion (0.0002 p.p.m.). Thresh (5) found 0.2 part per billion (0.0002 p.p.m.) phenol to give taste in tap or distilled water after addition of 0.25 p.p.m. chlorine. In Houston's own experiments (5) tap water containing 1.0 part per billion (0.001 p.p.m.) was found to give the characteristic iodoform taste when treated with 0.5 p.p.m. chlorine.

In the Toledo studies it was found that pure phenol, unchlorinated, could be detected by taste in undiluted Lake Erie water in a concentration of 25 p.p.m. The three cresols or their mixture, however, gave a taste in concentrations of 0.10 to 0.30 p.p.m. After chlorination the unmistakable chloro-phenol taste was detected in a concentration of 80 parts per billion (0.080 p.p.m.) in the case of phenol,

TABLE 4

Minimum concentration of pure phenol and chlorine required to give taste in filtered Maumee River water

Parts per million

PHENOL	CHLORINE	PHENOL	CHLORINE
0.001	0.092	0.025	0.675
0.002	0.115	0.050	0.175
0.004	0.161	0.100	0.125
0.005	0.253	0.200	0.125
0.010	0.138	0.600	0.075
0.015	0.184	0.800	0.075
0.020	0.450		

and 20 parts per billion (0.020 p.p.m.) in the case of the cresols. In attempting to duplicate the Toronto taste experiments (2) by various combinations of pure phenol and chlorine added to the filtered, but unchlorinated Maumee River water, the results in table 4 were obtained.

It should be remembered that the taste referred to in the foregoing experiments represents simply the minimum detectable taste which could be differentiated from the taste of the undosed water. Identification of an unmistakable chloro-phenol or "iodoform" taste required considerably larger concentrations than indicated in table 4, the minimum being 0.020 p.p.m. phenol in combination with 0.625 p.p.m. chlorine.

Summing up the available data, it would appear that the ordinary

taste range for pure phenol in drinking water lies between 1 and 20 parts per billion (0.001 and 0.020 p.p.m.). The cresols appear to be more far reaching in their influence upon water supply than phenol itself. The extent of taste depends upon the chlorine dose as well as upon the amount and kind of phenol present. If the values just stated should be found to be generally correct, it would seem feasible to determine quantitatively phenols lying mostly within the taste range. The figures given for the latter should be used with considerable reservation for taste sensitivity is extremely variable among individuals, both qualitatively and quantitatively. In offering the results of what might be termed a "side investigation" at Toledo, it is hoped to stimulate others to a trial of quantitative methods so that the permissible limits of phenol pollution may become reasonably established.

The authors wish to give acknowledgment to A. R. Kruger, C. A. Lindsay and John Forester, Assistants in the Filtration Plant Laboratory, for their helpfulness in connection with these studies.

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DISCUSSION

F. A. Dallyn:[4] There is very little to add to Mr. Donaldson's remarks, but it does occur to me from the very wide range of suggestions it might be advisable as a laboratory technique to include in the results the water from which the tasting took place, as the sensitiveness of the palate is affected very materially by the water.

[4] Consulting Public Health Engineer, Toronto, Ontario, Can.

C. M. BAKER:[5] As near as I can determine from the paper, the determination of phenol in water is rather complicated and involved, when considering the fact that phenol can be detected in such small dilutions, when the water is chlorinated. For a practical application it seems to me, especially when you want quick tests with limited laboratory detail, the methods used in the early Milwaukee investigation produce very satisfactory results. Those methods simply consisted of collecting the samples, chlorinating the water, boiling to drive off the excess chlorine and then detecting water taste or odors due to that waste.

That is a practical method that worked out successfully there. Mr. Cunliffe directed that work and in those early investigations in Milwaukee, it was demonstrated conclusively that it was the phenol waste that caused this objectionable taste.

I think Mr. Cunliffe could tell us something in regard to the work at Milwaukee that would be of practical interest.

RUSSELL W. CUNLIFFE:[6] In Milwaukee we considered the efficiency of each plant which we felt was a contributing factor to the case conducted. We took a twenty-four-hour sample and determined the amount of pollution which that would stand and which would be chlorinated and produce taste. We called that "taste producing power," or T.P.P. All the findings of that method have been subsequently worked out and proved true. Outside of this taste method used on the concentrated waste we did not think it essential to determine the amount of phenol waste.

L. H. ENSLOW:[7] I can only see one objection to the taste method. I think it has been ably shown that all depends upon how much chlorine is put into the water. On that ground it would be better to give the conditions from day to day, just the chlorine, gas and sewage analyses, or estimating the quantitative value, or semi-quantitative value. I cannot see where these investigations can check results on such a matter.

MR. CUNLIFFE:[6] This was not a river proposition. It was on the lake where there are no established currents. The taste so far as

[5]State Board of Health, Madison, Wis.
[6]Milwaukee, Wis.
[7]Chlorine Institute, Inc., New York, N. Y.

we were concerned was practically a method of concentrating on a solution of the problem. The chlorination taste is applied on effluents from the same plant with remarkable results.

LOUIS B. HARRISON:[8] I want to call attention to the effect that sunshine has on reaction of phenol tastes. If you try to determine taste by adding chlorine to the water in which there are traces of phenol in the presence of sunshine you are very apt to miss the taste entirely, because the sun's rays facilitate the action which a small amount of chlorine may have in connection with phenol so that the taste disappears immediately.

F. W. MOHLMAN:[9] I have been carrying out a few research tests on tastes, especially as founded on varying amounts of organic matter. I have found that iodine enters into the taste matter as well as other things already mentioned.

WELLINGTON DONALDSON:[2] In connection with Mr. Cunliffe's remarks it might be well to explain a little. We were striving to do two different things at Milwaukee and Toledo. At Milwaukee there were actual tastes in the water and it was a question of tracing them out with methods which would give results comparable with the consumer's perception.

At Toledo during this investigation it was not a question of taste usual in the water supply. It was a question of finding some numerical value for various waters collected from different points, rivers and lakes and wastes where a very wide range would be covered and obviously taste and odor methods would not be useful to us in that connection.

It occurs to me to suggest also that one possible defect about the chlorination and boiling method, one valuable factor besides those which Mr. Enslow names, is the time of boiling. I think that has to be taken account of. If the quantitative test has been made you will have to standardize the boiling time.

MR. MOHLMAN:[9] I would like to ask the gentleman from Milwaukee how many samples he could taste in one day? We found in Chicago that a man could taste just so much a day. When you taste

[8] Bay City Water Works, Bay City, Mich.
[9] Chief Chemist, Sanitary District of Chicago, Chicago, Ill.

two or three samples in a row and go back to your first taste, it will be different. There is a limit to the number of samples that a man can taste and test accurately in one day.

MR. CUNLIFFE:[6] We tasted as many as 200 and sometimes as high as 500 samples in one day. I am sorry we have not our charts here so we could show you the results. We classify the tastes in that way. We use three values, a very slight taste, strong taste and very strong taste. The taste factor is a peculiar thing. We have recorded our results and it was remarkable how different observers were on these different things, but at the end of the day we think our tasters were about in as good shape as they were in the beginning.

The plant on the Menominee River was about three miles out. We had some waste coming in from the Milwaukee River north and then we had also a source of taste from the coke plants down on the mouth of the river.

DANA E. KEPNER:[10] We have found in Colorado that by taking a drink of pure water, preferably distilled, and then taking the test sample we are able to get a very much better idea of the sample. We have also found that men who do not smoke have more sensitive tastes than the ones who do.

CARL J. LAUTER:[11] I have found the same thing in Washington. Personally I could taste it very well while some of the men could not detect it easily in the creosote chlorinated water.

WILLIAM C. LAWRENCE:[12] I want to compliment the authors on the good paper they produced, but I wondered how far we would have gotten in Milwaukee in detecting and curing the situation in the way of industrial wastes. We had nothing else to fall back on except taste and it certainly cleaned up a big problem. Later on we did this technical work. Of course, we did not have the sensitive taste that they have developed in England, but we did clear up the situation.

[10] Director, Division of Sanitation, State Department of Health, Denver, Colo.
[11] Chief Chemist, Filtration Plant, Washington, D. C.
[12] Superintendent, Filtration and Sewage Disposal, Cleveland Ohio.

CHAIRMAN HOWARD: Gentlemen, our work in Toronto has extended through the past twelve years and possibly has been as extensive as any work being carried on on the North American continent.

Mr. Lawrence mentioned a point which was in my mind, namely, that we all realize and know we have tastes, but we do not know in many cases from where the taste is coming. The tendency, as soon as taste occurs in the water supply, is to say it is chloro-phenol. In a large number of cases there is no evidence supporting the phenol theory at all. Where we have direct industrial phenol, where we have phenol discharges, creosote discharges or even industrial discharges of non-phenol content, the taste is perfectly clear, but there are far more cases which are obscured in the light of our present knowledge as to what is the definite cause of taste.

Mr. Dallyn raised a very important point bearing on the temperature. In most cases the worst taste is recorded in waters under the temperature about 45° Fahrenheit. I say in most cases. There are many cases where tastes occur at all temperatures, but the worst taste is reported from cold water. One theory is that the biological activity in the water as the water warms up destroys the phenols, thereby reducing the amount of taste noticed.

The preliminary work carried out in Milwaukee in 1919 substantiated that fact. We have a very marked seasonal variation, and to date no one appears to be quite sure what the cause is. It is a matter that I would like to touch on later regarding the treatment under seasonal conditions. We can get phenols directly as the result of decomposition, decomposing sewage and organic matter, which form small amounts of phenol which may react in the water in the presence of chlorine.

There is such a large combination of conditions, in spite of the great amount of work that has been done up to the present time, that we really are a little in the dark as to the cause of taste under many conditions. The work Mr. Donaldson carried out during the past four or five years has been very exhaustive and has brought forth much material. Yet the same technique carried out in other parts of the country has fallen down. It has fallen down quite badly for a series of reasons. The fact that the amount of applied phenol cannot be recovered in water has been observed in several places. We in Toronto have been able to recover about twenty to forty per cent of the amount applied in water we know perfectly

well did not contain phenol. In other words, the colorimetric tests indicate more phenol present than was actually in solution. This test was not a success and in fact failed in waters containing other agents which react to the treatment.

We found some of the tests were not consistent and contained acids and when we followed the work found alkaline wastes are less liable to taste. The work that has been ultimately limited to taste apparently is the one method which is receiving the most support in this meeting today.

RECENT ADVANCES IN CONTROLLING CHLORO-TASTES AND ALGAE DEVELOPMENT[1]

By L. H. Enslow[2]

It is once more the good fortune of American water works officials to profit from the experiences and researches of the English. Years ago, Sir Alexander Houston blazed the trail in chlorination and prechlorination of water on a large scale. This same investigator, justly termed "The Father of Chlorination of Water," has also shown, through his untiring researches, methods of reducing considerably and perhaps eliminating entirely the undesirable features of chlorination. Another Englishman, B. A. Adams (1) has succeeded likewise in combating the production of foul tastes sometimes present in chlorinated waters. To Houston (2) is due the major credit for progress in this direction. His statement of some years past that chlorine boldness rather than chlorine temerity will solve the problem of chlorine by-product taste prevention is rapidly proving to be well founded.

There are several types of organic matter which have the power of producing foul tastes and odors when in combination with chlorine. The simplest and probably the most common of these are the end-products of decay from vegetable and animal matter, including the essential oils liberated from algae growths. The more serious and less readily controlled organic pollution which causes taste with chlorine is that having its origin in the phenol and cresol group of compounds. Such polluting material enters the water supply in the form of industrial wastes or from domestic sewers, into which is discharged the waste from industrial plants or from hospitals in which phenolic disinfectants are employed.

In the first instance, the foul by-products may usually be destroyed by increasing the chlorine application and doing nothing further, except perhaps, subsequently storing the water for a few hours, or the super-chlorination process may be followed with aeration after a

[1] Presented before the Chicago Convention, June 10, 1927.

[2] Sanitary Engineer, The Chlorine Institute, Inc., New York, N. Y.

shorter period of contact. With the biological type of trouble-producing substances, super-chlorination of the water at some point ahead of the filters appears in certain instances to be all that is required. If necessary, a small dosage of chlorine may also be applied to the plant effluent for additional safety.

In the second instance, where the trouble may be termed chemical in origin, a more drastic super-chlorination, a period of contact, and finally dechlorination are required. For certain conditions, the addition of ammonia previous to chlorine application may reduce or eliminate chloro by-product tastes.

Chloro by-product tastes have resulted also from free chlorine in the water reacting with pipe coating material or other deposits within the mains, standpipes or tanks, to produce the foul taste in the distribution system, but not at the chlorinating plant. In such cases the only practicable remedy appears to be that of treating the water so as to prevent residual chlorine in the water when delivered to the distribution system. Pre-chlorination alone; use of ammonia in conjunction with subsequent or pre-chlorination; storage of the chlorinated water for sufficient periods; or the lowering of the pH value of the water, which insures a more rapid dissipation of the residual chlorine, are suggested procedures. In the last instance re-carbonation of softened waters or adjustment of chemical dosages applied for coagulation purposes and of the chlorine applied to the filter effluent appear feasible. A subsequent period of contact to allow fairly complete dissipation of excess chlorine before the water is delivered to the mains is also desirable.

SUPER-CHLORINATION AND DOUBLE CHLORINATION

At the White Rock filtration plant at Dallas, Texas, Bakke (3) has for the past three seasons successfully carried out super-chlorination of the raw water and subsequent chlorination of the filter effluent. This plan was practiced for destroying chloro products formed between the decomposition products from vegetable matter and algae in the raw lake water and the coagulation basins ahead of the filters. A rather high dosage of chlorine is applied to the filtered water, which at all times results in a residual chlorine content of 0.3 p.p.m. or more in the water entering the clear well of large capacity. No complaints from excess chlorine or by-product tastes are heard from consumers during such operating conditions, whereas, prior to such drastic chlorination, complaints were many and continuous.

The average dosage of chlorine applied to the raw water is sufficient to produce 0.35 p.p.m. residual at the entrance to the coagulation basins.

DOUBLE CHLORINATION AND pH ADJUSTMENT

At the Turtle Creek plant at Dallas, Texas, where iron sulphate and lime are employed to coagulate and soften the supply ahead of the filters, Bakke employs double chlorination. The filtered water is chlorinated as it enters a large open clear-water storage basin and again as it leaves the plant for delivery directly into the distribution system. Investigation disclosed that such tastes were being formed within the mains and never in the clear-water storage basin at the plant. The solution of the difficulty was found in the adjustment of the chemicals applied to the raw water. Lowering of the pH value of the filtered water prior to chlorination resulted in the elimination of stabilized available chlorine compounds produced when chlorine was added to the water with a higher pH value. The end result was an increased dissipation of the available chlorine. This meant that residual chlorine in the water reaching the offending sections of the distribution system and dead ends was absent or else was insufficient to produce the foul tasting by-products within the mains. As will later be shown in recounting the experiences of McAmis at Greeneville, Tenn., it is probable that an application of ammonia to the water ahead of chlorination would have solved the difficulties equally as well as regulation of the chemical dosage causing more rapid dissipation of the chlorine. The latter effect is probably a result of eliminating either the formation or the stabilization of hypochlorites in the water.

Bakke (3) points out that, had re-carbonation of the settled water been possible, this process would have been employed rather than the reducing of the lime and increasing of sulphate of iron. Prior to adjustment of pH value of the water ahead of chlorination, super-chlorination without dechlorination had been tried without success.

SUPER-CHLORINATION AND DECHLORINATION

For the past several years Norman J. Howard, at the Toronto, Ontario, filter plants has been conducting laboratory scale experiments in connection with the chlorination of waters containing phenols, cresols or their derivatives. This work had been conducted simultaneously with that of Sir Alexander Houston. As a result of

the favorable outcome of the work of Houston, which agreed with the observations made by Howard, Howard and Thompson (4) in 1926 carried out a thorough investigation into the actual quantities of chlorine required and the contact period necessary to destroy the various phenols or cresols. Complete data as to the quantity of chlorine required for phenol destruction by super-chlorination followed by the contact period available at the Toronto plant and the quantity of sulphur dioxide later required to reduce the excess chlorine to that desirable before discharging the water to the mains was presented to the city authorities. Adoption of the process was authorized in the late summer of 1926. It proved to be immediately effective.

In the application the entire plant output delivered to the city (70 m.g.d.) was from the first super-chlorinated. The dosage of chlorine applied to the effluent of the filters was between 0.75 and 1.25 p.p.m. followed by an average period of contact of one and one-fourth hours. Sulphur dioxide (0.28 to 0.62 p.p.m.) was next applied to the super-chlorinated effluent at the pump station delivering to the mains. The application of the sulphur dioxide gas was made from cylinders of liquid sulphur dioxide connected to Wallace and Tiernan vacuum type chlorinators which were fitted with special orifices and other parts where necessary. These machines have performed satisfactorily and are operated by an attendant who adjusts the dosage so as to barely destroy all residual chlorine in the water delivered into the mains.

Howard reports that, whereas the theoretical relationship between the sulphur dioxide necessary to destroy a given excess of chlorine is 0.9 pound of sulphur dioxide for 1 pound of chlorine, it appears in actual practice that 1 part of chlorine requires 1.12 parts of sulphur dioxide, i.e., a quantity of 25 per cent in excess of the theoretical. Under certain conditions as much as 50 per cent in excess was required. During heavy rates of discharge the pressure in the sulphur dioxide cylinders was difficult to maintain unless a temperature above 80°F. was provided, or unless a relatively large number of cylinders were connected to each machine. Recently steam coils have been placed between the cylinders to facilitate rapid delivery of the gas.

A small portion of the Toronto supply could not be super-chlorinated and de-chlorinated. During the first period of super-chlorination the main supply developed no taste, whereas that not super-

chlorinated was noticeably foul tasting. During a short period after beginning super-chlorination the sulphur dioxide supply was exhausted and with the discontinuance of super-chlorination the foul taste returned to the main supply.

Super-chlorination and dechlorination have been applied to 70 m.g.d. flow at Toronto for a total of eighty-four days. It was discontinued December 8, 1926, because of lack of necessary appropriation. Immediately following discontinuance foul tastes developed and persisted for a few days until the wind direction changed and the pollution was driven from the vicinity of the raw water intake. Since then complaints have been intermittent, depending upon the meteorological conditions.

Howard recently reports that a greater chlorine dosage is required at times when the water temperature drops below 42°F. Although 1.25 p.p.m. appeared sufficient under summer and fall conditions, the cold water during winter requires as much as 2.00 p.p.m. to be effective with the contact period available, viz., one and one-fourth hours. This situation is believed to be a result of lessened biological activity in the raw water in cold weather and therefore a greater concentration of undestroyed phenols with which super-chlorination must cope.

The City Council has sanctioned the return to super-chlorination and dechlorination at Toronto and has appropriated the necessary funds for equipment of increased capacity. Within a short time the process of super-chlorination and dechlorination will be in use again. The estimated cost even with the heavy winter dosages will amount approximately to $32,000 per year with continuous application. The cost of treatment will average something less than $1.75 per million gallons. The use of chlorine in ton containers at the Toronto plant would reduce the cost of super-chlorination materially.

Harrison (5) who has conducted laboratory experiments at Bay City, Michigan, has confirmed the results reported by Howard and Thompson in their preliminary work at Toronto. Harrison finds also that it is imperative to insure a sufficiently high residual chlorine (never less than 0.6 p.p.m.) and thereafter a contact period of two hours prior to dechlorination. Harrison finds, as Howard has, that a gradual increase of chlorine applied to water containing phenols will produce a foul taste, which upon further increase of chlorine will be lessened and finally will disappear. Further increases again result in re-appearance of foul tastes and finally super-chlorination

effectively and permanently destroys the taste after the necessary contact period has been allowed.

THE AMMONIA-CHLORINE PROCESS

In Canada, Race (6), for sterilization purposes, successfully employed a mixture of hypochlorite solution and weak ammonia water. Improved taste of the water so treated was secured at the expense of rapid sterilization. Thresh (7) also reports the successful use of this method in England at a water works using river water. Major Harold (8) of the British Army has succeeded in producing chloramines from chlorine water and ammonia water and in obtaining a patent on the process of first producing chloramines from chlorine gas and ammonia solution and thereafter applying such solution to the water, etc.

In England both Sir Alexander Houston (1, 10) and B. A. Adams (2, 9) reported very effective results obtained in chloro-taste prevention, when applying ammonia in conjunction with liquid chlorine. Houston applies the ammonia to the water prior to the chlorine application. Adams prefers to mix the ammonia solution and chlorine solution just prior to admitting the mixture to the water. Houston refers to the latter method as that of Harold (8) and, after comparison of the two methods experimentally, points out the various advantages and economic aspects of each method. On the whole, Houston favors the application of the ammonia to the water at a point ahead of the point of chlorine application. Comparing the use of permanganate ahead of chlorine application with the ammonia-chlorine combination the results are in favor of the latter method. Houston points out that application of approximately 0.25 p.p.m. of ammonia (NH_3) is sufficient in most cases to *prevent* taste production when the chlorine is later applied. On the other hand, *ammonia added after chlorination will not remove the chloro-taste* once it has been produced.

Adams (9) claims greater efficiency from the Harold process and prefers gaseous ammonia to ammonium salts in any event.

At Greeneville, Tenn., during the past several years complaints of "iodoformish" chloro-tastes have been frequent during the summer months. The water supply is derived from a limestone spring not subject to pollution by phenol wastes or other industrial wastes. This normally clear, but hard, spring water is softened and clarified with lime and iron sulphate, and thereafter filtered. To eliminate

the intermittent chloro-tastes J. W. McAmis, superintendent of the water works, attempted to super-chlorinate without subsequently dechlorinating and later tried double chlorination also, without material success in either case. In double chlorination a primary dosage was applied to the raw water and the secondary dosage applied to the water leaving the clear well to enter the distribution system.

It is interesting to note in the report of McAmis (11) that the chloro-tastes never developed in samples collected at the softening plant and even in the distribution system in which the tastes developed intermittently. The water temperature range during taste production always was found to be between 17° and 23°C. He further points out that a possibility exists wherein the pipe coating material or foreign substances within the service tanks or mains might be the source of the taste production.

In any event, not having attained success in various other attempts at taste eradication, McAmis, familiar with the ammonia-chlorine combinations used by Houston with success, attempted the use of ammonia water prior to the chlorine application. This marks the first attempt on a plant scale with this process in America.

In the first trial ammonia water was applied to the raw water prior to application of softening chemicals. The chlorine was applied, as previously, at a point about half way of the mixing chamber and after the softening chemicals had begun to coagulate in the water. The process was an immediate success and chloro tastes entirely disappeared from the distribution system. Discontinuance of ammonia application resulted in the re-appearance of chloro-tastes.

Having had undeniable success with this scheme, the ammonia application was continued to the raw water, but the point of chlorine application was changed to the filter effluent. The tastes were not formed under the latter operating procedure and therefore the chlorine application to the filter effluent continues to date. McAmis (11) points out, however, that the lagging of efficiency of sterilization was observed when employing the ammonia-chlorine treatment and thus a longer period of contact is required than otherwise. It would appear, therefore, that with absence of sufficient contact elsewhere the chlorine should be applied at the inlet end of the coagulating basin.

McAmis also calls attention to the very slow development of maximum color when ortho-tolidin is added to the ammoniated-chlorinated water, presumably containing chloramines rather than free chlorine or hypochlorites.

METHOD OF PREPARING AND FEEDING AMMONIA

The high solubility of ammonia gas in cool water enables one to prepare the ammonia solution quickly with simple equipment. A mixing device and gas diffusor are not essential in the dissolving tank but may prove advantageous. The ammonia water is fed from an ordinary orifice box.

AMMONIA REQUIRED

At Greeneville, Tenn., 0.25 p.p.m. (2.08 pounds per million gallons) ammonia (NH_3) apparently gave satisfactory results at all times and at times even lower dosages also proved effective. Increased dosages failed to impart any taste to the finished water.

A tank of 100 gallons solution capacity should serve when applying ammonia at the rate of 0.25 p.p.m. to water passing at the rate of 10 m.g.d. for seven hours. The strength of solution prepared would be 0.75 per cent of NH_3 by weight, i.e., 6.25 pounds of ammonia gas (NH_3) in 100 gallons of water. If loss of ammonia is noticeable the solution strength should be reduced and increased tank capacity provided. The ammonia solution should be delivered from the tank into the water with a minimum of free fall or splash.

COST OF TREATMENT

Houston (2) reports cost of chemicals in the ammonia-chlorine process to be 41 cents per million gallons of water treated.

McAmis (11), operating on a much smaller scale and with higher cost of chemicals, reports the cost to be about 60 cents per million gallons treated.

PREVENTION OR RETARDATION OF ALGAE DEVELOPMENT

Within the past year attention has been directed toward the use of chlorine for the dual purpose of bacteria reduction and algae growth prevention when applied to the raw water entering coagulation basins, service reservoirs or swimming pools. For some years prechlorination has been effectively used in several places to increase the efficiency of coagulation, reduction of wash-water and biological growths in the filter beds and underdrains. Cohen (12) reports on the successful application of chlorine to reduce and thereafter retard algae growths in settling basins at Lufkin, Texas, and in a service reservoir at Mexia, Texas. The results secured so far indicate that

certain forms of algae are more resistant to copper sulphate than to chlorine and, further, that in certain instances the use of copper-sulphate will prove more expensive. It would appear that application of chlorine to insure a residual of 0.5 p.p.m. will effectively kill most forms of algae so far encountered.

At Mexia, Texas, R. F. Morgan, superintendent of water works, has apparently improved the process of algae control with chlorine by application of hydrated lime simultaneously with the chlorine. The result obtained appears to be a retardation of residual chlorine dissipation in the service reservoir and thus a more lasting effect from the chlorine application is secured. The dosages used on this clear water are approximately 8 pounds of hydrated lime and 6 pounds of liquid chlorine per million gallons treated. Certain forms of algae resistant to 15 p.p.m. of copper sulphate were by this process eliminated.

At Texarkana, Texas, it is reported that chlorine has been successfully used in an outdoor swimming pool for the sole purpose of destroying algae growths and retardation of subsequent algae development.

At Lufkin, and Mexia, Texas, in 1926, considerable economy has resulted by reducing the frequency of basin cleaning at the former and copper sulphate additions and reservoir cleaning at the latter named place. Further tests at Mexia during the summer of 1927 will serve to check the results obtained in 1926.

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DISCUSSION

C. R. Cox:[3] Mr. Enslow's review of the problems of preventing tastes in chlorinated water summarizes the latest developments in this interesting field. The purification of water, is becoming a more complex problem as the raw water becomes more heavily polluted and because the public is demanding water which is physically attractive as well as safe from a sanitary standpoint. In fact, the prevention of tastes is attracting as much attention as that heretofore given to the problems of producing bacteriologically pure water.

The prevention of pollution of water supplies by taste producing substances should be given precedent over the treatment of waters to remove such material. Such pollution inevitably occurs at times, however, and then taste removal is a serious problem. It may be of interest, therefore, to review briefly the experiences at two water purification plants in New York State where phenol taste problems have arisen, because a phenol waste disposal plant was placed in use at a coke plant in one instance to prevent such tastes from developing, and potassium permanganate treatment has been utilized at one of the water purification plants to destroy such taste producing substances present in the raw water. Both of these plants are under the direction of James M. Caird, Chemist, of Troy, New York.

The small mechanical filtration plant at Rensselaer, New York, treats heavily polluted Hudson River water. Chlorine is applied at two points, namely, from 0.75 to 1.5 p.p.m. to the raw water, and from 0.25 to 1.0 p.p.m. to the filtered water. These doses are based upon the destruction of the large number of B. coli present in the raw water, and not upon the maintenance of any definite quantity of residual chlorine in the filtered water, although such residual is obviously determined from time to time as a secondary guide. Smaller

[3] Assistant Engineer, State Department of Health, Albany, N. Y.

doses of chlorine would be feasible if the period of sedimentation were greater than the one hour available, because this would provide longer periods of contact for the action of the raw water chlorine dose, which would thus disappear to a large extent before the water passes through the filters.

Oxygen consumed values of this raw water vary from 7.0 to 25.0 p.p.m. Notwithstanding this high organic content, the final effluent has a satisfactory taste at many times, provided the residual chlorine is removed by the use of some anti-chlor, such as sodium thiosulphate. Independent of the distinctive chlorine taste, there is a bitter, musty taste in the filter effluent at times which disappears when an anti-chlor is added to the water. This would indicate that this taste is due to unstable reaction product of chlorine and organic matter, such as the sulphite pulp wastes present in the river water.

Notwithstanding the prevalence of the true residual chlorine taste and this other bitter taste in the filter effluent at times in the past, serious complaints were not received from the consumers until the fall of 1925 when the Hudson Valley Coke and Products Corporation constructed a large coke oven and gas plant in South Troy about 5 miles above the intake of the Rensselaer water supply. This corporation installed, at the instigation of the State Department of Health, a phenol recovery plant whereby it was hoped to prevent the discharge of phenol into the river. A similar plant is in use at the Iroquois Coke Plant at Buffalo, New York and at a coke plant in Lorain, Ohio. These plants have been described in the literature, but it may be of interest to give the essential details at this point.

Ammonia liquors from the primary coolers of the coke plant contain practically all of the phenol wastes washed from the gas. These liquids are pumped through benzol scrubbers where the phenol is absorbed by the benzol. The benzol is then pumped through water scrubbers to remove carbon dioxide and then through caustic soda scrubbers where sodium phenolate is produced. The de-phenolated benzol is then pumped back to the benzol scrubbers and re-used. The sodium phenolate is treated with sulphuric acid whereupon sodium sulphate and phenol are formed. The efficiency of the plant varies from 80 to 98 per cent, although at most times the efficiency is between 90 and 95 per cent. The coke plant produces from 200 to 300 pounds of phenol per day when the production is from 1200 to 1500 tons of coke, so that from 10 to 30 pounds of phenol remain in the ammonia liquors discharged into the river each day.

Formerly these ammonia liquors were discharged onto incandescent coke where approximately 50 per cent of the phenol was evaporated. Odors due to ammonia were claimed to be produced by this procedure so that the piping system was modified and the ammonia liquors were discharged directly into the Hudson River. This intensified the tastes at Rensselaer so that the discharge has been limited to the period between 6 a. m. and noon, in order that most of the wastes would pass down the Hudson river below the intake before the filtration plant at Rensselaer is started each day at 5 p.m. This modification has improved the quality of the water pumped through the intake.

Notwithstanding the removal of most of the phenols from these coke plant wastes and the rather large dilution obtaining in the Hudson river, obnoxious chlorophenol tastes have occurred in the Rensselaer water supply at frequent intervals, especially during the winter of 1926–1927, during periods of relatively low stream flow, and before the discharge of the wastes was regulated to suit the operating schedule at the filtration plant. Several accidents have occurred whereby large quantities of phenol have been released into the river, and for over a month in 1926, the phenol recovery plant had to be shut down for repairs and remodeling. Due to this situation, the coke plant chemists are carrying on research work with a view to improving the efficiency of their phenol recovery plant.

The practice of super-chlorination to destroy chlorophenol tastes, such as at Toronto, Canada, cannot be utilized at Rensselaer, New York, due to the physical limitations of the filter plant. In the meantime, the spring run-off has supplied sufficient diluting water to prevent tastes from being noticeable. It is possible that the tastes may be prevented in the future by the ammonia method as practiced at Greeneville, Tenn. or by the potassium permanganate method first utilized by Houston in London and now being used at Rochester, New York.

The Rochester and Lake Ontario Water Company maintains a pressure mechanical filtration plant which treats Lake Ontario water. The intake is located about 4000 feet from shore at a point about one mile west of the mouth of the Genesee river, on which the city of Rochester is located. At most times relatively clear Lake Ontario water, with a low organic content, is pumped through the intake, but, when the winds are easterly, the polluted river water is driven towards the intake. Marked modification in the character of the lake water appears at such times so that effective chlorination

is rendered more difficult and obnoxious tastes are produced when chlorine is added to the water. It is a well known fact that large quantities of chlorine cannot be added to water from the Great Lakes without the production of tastes due to residual chlorine. It is fortunately possible, however, to chlorinate such water with relatively small doses of chlorine. Thus the average dose of chlorine for 1926 at the Rochester plant was about 0.3 p.p.m. This dose is applied at two points, to the raw water, where the dose varies between 0.15 and 0.56 p.p.m. and to the filtered water where the dose varies between 0.036 and 0.077 p.p.m. These very small doses of chlorine at most times lead to the presence of a slight residual in the treated water and satisfactory bacterial removal has resulted. During periods of easterly winds, however, it is necessary to increase the raw water dose to 0.9 p.p.m. Even then no residual chlorine was present in the filtered water and obnoxious chlorophenol tastes were developed. It was known that industrial wastes from the Eastmen Kodak plant and the gas plant of the Rochester Gas and Electric Company were discharged into the river. As these wastes could not be treated at once, potassium permanganate was utilized at the filtration plant in an endeavor to destroy the taste producing substances.

After some preliminary studies it was found that satisfactory results could be secured by such treatment when potassium permanganate solution was added to the raw water in relatively small quantities. This chemical is not added at all times, but the absence of the usual amount of residual chlorine in the filtered water is used as a criterion for the addition of the potassium permanganate. In other words, when normal lake water is passing through the intake and small doses of chlorine produce satisfactory residuals, no potassium permanganate is utilized, but during periods of easterly winds the quantity of organic matter present in the raw water increases, the residual chlorine disappears and the potassium permanganate treatment is utilized. It has been found possible to destroy the taste producing substances by the addition of from 1.0 to 1.6 pounds of potassium permanganate per million gallons of water treated. The use of this chemical enables the original chlorine dose to be utilized without the production of chlorophenol tastes and with the maintenance of the desirable trace of residual chlorine in the filtered water. To date very satisfactory results have been secured. It should be remembered, however, that manganese is an undesirable constituent in water when present in quantities greater than about 0.3 p.p.m.,

due to the fact that articles of clothing are stained by the manganese. As the effective doses are low, this practical objection should not be important, although the use of other oxidizing substances should be investigated. The organic matter in the water reacts with the permanganate and thus colors due to this compound are not formed.

Commercial potassium permanganate purchased in large quantities may be obtained at about 18 to 25 cents a pound, depending upon the quality of the material and the quantity purchased.

About 20,000 gallons of ammonia liquors are produced at the gas plant of the Rochester Gas and Electric Company each day. These liquors contain about 350 pounds of phenol, so presumably this phenol was the cause of the obnoxious tastes noted above. Studies are being made by the officials of the city of Rochester, in coöperation with the officials of the gas company, relative to the possibility of discharging these wastes into the city sewers without the biological processes at the sewage disposal plant being affected thereby.

The wastes from the Eastman Kodak plant contain only small quantities of phenol-like bodies, but relatively large quantities of organic wastes. Studies are being conducted relative to the installation of an organic waste disposal plant at this factory. This plant should eliminate marked changes in the chlorine demand of the lake water and should thus improve the efficiency of chlorination.

PAUL HANSEN:[4] I would like to mention that Mr. Enslow did not speak at any length on the use of chlorine in the conditioning of the sand bed. There is an opportunity for extending the use of chlorine. One of our great difficulties in the operation of filter plants using lake water is short run troubles, clogging of beds, mud balls, drawing of the sands away from the sides of the filters, etc. It may be possible with the skillful and proper application of chlorine, together with proper analytical control, principally through the microscopic examination of sand grains as described by Mr. Baylis, to have a means of conditioning our beds as a routine matter of filter operation.

I would like to say a word about the reason why in some places the effect of phenol tastes is more pronounced in winter than in summer. Many of these phenol wastes are discharged from the industries at a more or less high temperature. In the winter these wastes coming close to the surface of the water are cooled down to a point of maxi-

[4] Of Pearse, Greeley and Hansen, Consulting Engineers, Chicago, Ill.

mum density and sink. In the summer they continue to float in a warm condition on the top of the water and do not go down and thus do not reach the intakes. This was very clearly observed at Marquette, Michigan, where the coater supply is affected by phenol tastes resulting from the discharge of wastes from a charcoal by-products plant.

I trust that Mr. Enslow will make papers of this sort and character an annual affair. There is nobody in the country who is in a better position to keep track of the developments in the use of chlorine as applied to the treatment of water than is Mr. Enslow. We would appreciate an annual summary of the status of the art and practice of using chlorine.

HOWARD E. MOSES:[5] To my mind, there are at least two cases where pre-chlorination is of advantage. First, where a heavy pollution load is on the filters and the dose can be split and possibly avoid the after taste from chlorination where it is all applied after filtration. The other is where the filtered water product goes directly to the consumers and all chlorine is added in the clear water. To keep down the tastes and odors under these conditions is very difficult. There are various degrees between those two.

Several plants illustrate this. There is a large plant on the lower Delaware River that is very heavily loaded on account of the stream being grossly contaminated with both sewage and industrial waste. They started pre-chlorination, splitting the dose, and introduced the preliminary dose at about the same time the coagulation in the waters began. The water is chlorinated again before it goes into the system. In this instance it is pumped directly to the main. This plant which serves 70,000 people seems to operate successfully without causing complaints.

There is another plant on the Schuylkill River, where pre-chlorination has been started in the last few years. This water is not as heavily polluted as that of the Delaware River.

As a contrast, I know two plants that are on upland streams. On one of them, a short time ago, a distinct musty odor developed. As a matter of experiment pre-chlorination was tried. It worked so well that they have been continuing it every since. The same company has another plant where they pre-chlorinate. It is interesting

[5] Assistant Chief Engineer, State Department of Health, Harrisburg, Pa.

to note in this connection that they treated it this year also with copper sulphate.

We had at one plant two instances of trouble from phenolic compounds caused by the draining of roads that had been freshly oiled by the Highway Department. There is not much that can be done. In this particular instance the water company is keeping a very careful watch on the road oiling schedule of the Highway Department so as to be on the lookout for any further trouble of that sort.

MALCOLM PIRINE:[6] May I suggest something that might be advantageous in a number of plants for conditioning the sand beds in the treatment of wash water. We are finding the condition of wash water which may help to remove continually the tendency to form a film on sand.

In one of our plants we have used a relatively hard well water for wash water. Possibly there are other locations where that might be done. I have not gone far enough with it yet to determine just how effective that is in cleaning off the film that forms on sand grains. We do not want to treat the water going through the filters, because we want that film to work just as hard as it will in removing all impurities in the passing water.

The plant that I have in mind is one at Rahway, New Jersey, where they were having very bad troubles with odors. It was apparent that it was partly due to filters which were not working properly. It was a pressure filter. The water was coagulated and pumped to a standpipe. The standpipe acted as a coagulating basin and the water passed back through the filters into the mains, receiving chlorine directly in the mains as it left the filter plant. There was a substitute plant to be used during excess turbidities of the river water that consisted of a coagulating basin. The water from that passed through the pressure filters and up to a clear well. The water from the clear well was pumped into the distribution system, the standpipe acting as a pure water standpipe.

The development of super-chlorination in getting rid of industrial tastes, from phenols which were coming down from the river from a chemical plant at a little distance above the intake, gave us the idea of using exactly the structures that were there in revamping that plant and simply adding to it. We increased the coagulating

[6] Consulting Engineer, New York, N. Y.

basin and introduced aeration. The water flows from the coagulating basin onto the top of the gravel filter and receives the chlorine dose as it enters the clear well. There is a retention period of several hours in the clear well. We had to use that pressure filter house for something and it worked out very well, considering possibilities of future treatment, by leading the water from the clear well to the aerating system in the old pressure filter house.

The water flows to fixed nozzles with a variable nozzle which is controlled by a float, maintaining a definite head of water on the suction of the pumps.

If the chemical industry gets out of the control of the Board of Health and discharges a lot of stuff into that water which requires super-chlorination to overcome the tastes produced by it, they can apply all the chlorine they want, which has been satisfactory to Mr. Enslow. If anybody interested in the use of chlorine will keep away from the windows and the aerator or air house, most of the excess would go off there. We have found by experiment that excess chlorine would go off in the spray of the aerator after the water was properly cleaned up. And then it will not be necessary to use as much sulphur dioxide, which is an expensive chemical, in finally dechlorinating the water as it goes into the mains.

J. W. McAmis:[7] There is nothing I could add to what has already been said, except in the nature of second hand material. I would like to add my homage to Sir Alexander Houston and some of the others that have pioneered in chlorine and taste treatment.

There is only one thing that seems to me ought to be impressed on water works people and that is the ease and simplicity of the ammonia treatment we have been using in Greenville. As my operator said, "it is just like falling off a log, nothing to it, works very nicely, and if you get a little too much you have no trouble, it makes no taste at all in the water."

Louis B. Harrison:[8] In my experience I have found that, in order to destroy the phenol tastes, the reaction period is of great importance. A minimum of two hours is required at Bay City. After the chlorine excess has been destroyed, no matter how long the sample stands in the laboratory, the taste does not reappear. In all these cases the minimum reaction period must be determined.

[7] Superintendent, Water Works, Greenville, Tenn.

[8] Water Works, Bay City, Mich.

I have remarked before that violet rays tend to alter the reaction. We ought to determine what effect violet rays in combination with super-chlorination will have. I have not been able to perform any experiments with ultra-violet rays, but I am going to do so in the future.

I have also experimented in a plant on super-chlorination of musty tastes. I have met with great failure and disappointment. Whereas the super-chlorination did remove the musty taste, it produced in its stead a sort of weedy taste that was worse than the original musty one.

FLOYD W. MOHLMAN:[9] Mr. Enslow referred to some laboratory tests that we made in the sanitary district. This is a little out of our field, but in addition to our sewage work we collected some fifty or sixty samples a day from the suburban cities in the neighborhood of Chicago from Waukegan to Gary. We are making a study of bacterial efficiency of these plants, of the tastes and odors received in the Calumet District. The Calumet District has a number of by-product coke plants and industrial wastes of other character. We felt we might make a little study of what could be done with those wastes, stimulated to some extent by Mr. Enslow's visit.

On the Calumet waters we found it was necessary to use a considerable excess of chlorine, that is, certainly more than 1.00 p.p.m. for super-chlorination and then we require quite a period of contact. I think Mr. Harrison has referred to that. He said a minimum of two hours and Mr. Howard stated one and a quarter. That is a part of the process that requires time, and I think it will vary with various waters. We found it might take four or more hours, with the tastes in the waters with which we were working.

The next step in the dechlorination with sulphur dioxide is an immediate reaction and proceeds very nicely. We have used sodium dioxide or sodium sulphite can be used. We found that frequently there is a musty taste remaining after dechlorination. I believe Houston reports on one of the upland waters that a musty taste remains.

There is another point in regard to sulphur dioxide. A certain amount will be oxidized by the dissolved oxygen in the water, and

[9] Chief Chemist, Sanitary District of Chicago, Chicago, Ill.

the per cent of efficiency will vary somewhat, although I think Mr. Howard has worked out the per cent that he used in this reaction.

Those elements should be considered and each water should be studied on its own basis. We have another interesting experience with regard to pre-chlorination. There are two filter plants treating approximately the same type of water, highly polluted, with the B. coli index up to 50,000. East Chicago has been pre-chlorinating for some time. Whiting has not been pre-chlorinating and we find that East Chicago, using rather large amounts of chlorine, has been able to produce an effluent which meets the present standards for the past year without any exceptions, while Whiting, using we will say 5 or 6 pounds of chlorine, has not been able to meet that standard continuously. The difference is this. East Chicago applies the chlorine at the entrance to the coagulation basins and applies very large amounts. We have a record of one day when they applied 25 pounds per million. About 80 per cent of the chlorine is applied before the sedimentation acts and the remaining 20 per cent to the filtered water.

They are able to get the results by using these large amounts of chlorine. If it is a question of either producing tastes and odors or producing a safe water, I think they will have to use those amounts. It indicates to us, however, that where these highly polluted waters must be treated by pre-chlorination so as to produce a water meeting the new standard, considerably larger amounts of chlorine can be used. Whether that is economical is a debatable question, but it has been shown very conclusively that, by using these larger amounts, waters of the same character will show different results with the bacterial efficiency decidedly in favor of the plant using pre-chlorination.

SHEPPARD T. POWELL.[10] It may be of interest to the men here to know what was done at the Avalon Plant of the Baltimore County Water Company in 1910. We started the use of chlorine at that time employing bleaching powder, the only chemical available. We had no idea how much to apply and we were using between 1 and 2 parts per million. The treatment was started in 1910, after the plant had been operating two years. The chlorine was applied at the entrance of the coagulating basin. The average result after five years

[10] Consulting Chemist, Baltimore, Md.

of treatment, compared with the two years before using the treatment, showed an increase in the lengths of runs of the filters of about 25 per cent. The wash water was reduced about $\frac{1}{2}$ of 1 per cent.

We later tried double treatment applying three-quarters of the dose before application to the filters, and about one-quarter after the filters. No tastes or odors resulted from the treatment. Our experience showed that the pre-chlorination removed the growths on sand beds and materially improved operating conditions.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

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Proceedings of Ninth Texas Water Works Short School. Texas Section, Southwest Water Works Association. January 24–29, 1927. These proceedings are divided into sections as follows: Section I. General; Section II. Water; III. Laboratory Methods and Control Studies; IV. Sewage Disposal; V. Appendix. **Section II: Raising the Standard of Public Water Supplies in Texas.** J. B. BAITY, 46. State Board of Health requires that plans and specifications for water works improvements be submitted for approval. The "Monthly Water Works Operation Report" form furnished by the State Board of Health and submitted by a number of cities in the state is designed to set forth a complete record for each day of the operation of the plant. Plants without laboratories are urged to submit samples regularly to the State Board of Health laboratory. **The New Three and a Half Million Dollar Water Supply, Waco, Texas.** O. N. FLOYD, 51. Water will be obtained from Bosque River by the construction of an earth dam of about 7000 feet total length. Basin formed will cover about 4500 acres and will store twenty-five billion gallons of water. Three and a half miles of 36 inch pipe will convey water to existing five million gallon filter plant. **Comparative Water Service in Texas Towns.** B. F. CHERRY, 57. Writer offers a basis upon which a water rate should be built in a town or city, municipally or privately owned. **A Texas Water Supply Enlargement Problem Involving a Dual Distribution System.** N. T. VEATCH, JR., 59. In arid and semi-arid parts of the country the large amounts of water used for irrigation places a heavy load on an otherwise adequate water supply, raising the question of economy in a separate system for irrigation. Wichita Falls is cited as an example where excessive use of water for irrigation has resulted in several near water shortages. Additional supply available is a hard and saline water suitable for irrigation, but not domestic use. Figures are given showing comparative costs of single and dual systems. Dual system is more expensive in first cost and in operation than single system, but should be considered where sufficient water is not available or supply requires excessive chemical treatment. **The San Antonio Flood Control Program.** S. F. CRECELIUS, 63. **Garza Dam and Reservoir Project Now Under Construction by the City of Dallas, Texas.** J. C. NAGLE, 72. Tabulation of dimensions, quantities, costs, items, etc. **Status of State Water Conservation Program for Levee Districts.** B. F. WILLIAMS, 75. **Financing City Water and Sewer Improvements.** TERRELL BARTLETT, 78. **Public Policy and Water Works**

Management. J. Z. MARTIN, 82. Greater politeness, more patience and courtesy and more sincere effort to obtain and keep the goodwill of the public is stressed. A water company should not only keep abreast of the times in its equipment for filtration and transportation, but also with changes involving office management. One hundred per cent metering and monthly billing are advised. **Responsibility of Water Works Officials in the Distribution of Water.** F. J. VON ZUBEN, 85. "An official who, taking office, neglects to investigate the condition of the public water supply and do everything in his power to make it adequate, betrays a sworn public trust and is a liability to his community rather than an asset." **Liability of a Municipality for the Quality of Water.** H. J. DARCY, 87. List of cases is given, in which decisions were rendered in favor of plaintiff on the basis of negligent operation or maintenance. **Cost, Accounting, and Records in Running a Water Works.** W. H. DEATON, 89. **Electrification of Water Plants.** F. C. BOLTON, 92. Characteristics of reciprocating, rotary and centrifugal pumps is given, together with description of squirrel-cage induction, wound-rotor induction, synchronous and brush-shifting commutator motors. Advantages of pumps and motors and features to be considered in their selection is discussed. **Appraising Water and Sewer Systems.** R. E. MCDONNELL, 103. **Trained Personnel Versus "Hired Hand" Method of Filter Plant Operation.** G. F. CATLETT, 109. An important cause of poor condition of filter plants is neglect or incompetent supervision. In North Carolina a systematic training and development is given by the State Board of Health. In addition to improvement in plant efficiency and greater assurance of safety, considerable economics have been effected, proving that the trained operator really does not cost any more than the man hired at random, without any regard for the qualifications required in handling water purification. **Combination Water Works and Sewage Disposal Plant Operators.** E. W. STEEL, 113. **Supervising Water Improvements in California.** C. G. GILLESPIE, 115. **Dual Water Supplies.** A. L. DOPMEYER, 120. **Developing and Protecting Underground Water Supplies.** J. G. MONTGOMERY, 125. **Economy of Softening Well Water Supplies.** PAUL C. LAUX, 129. In order to give comparative figures the author uses hypothetical community of 25,000 inhabitants, using water of 400 p.p.m. hardness. Figures indicate softening by municipal lime-soda softening plant, to cost approximately two-thirds that of softening by individual household softening plants. Discussion by Sidney B. Armsby gives figures for M. K. & T. Railroad softening plant at New Braunfels, Texas, as compared with same water delivered to town without softening. **Zeolitic Water Softening.** RAY RILEY, 139. **Water Softening as an Adjunct to Water Purification.** CHARLES P. HOOVER, 143. Softening process increases efficiency of filtration plant operation because better coagulation is effected, more organic matter and color are removed, the treated water is non-corrosive and intestinal and pathogenic bacteria are killed. The killing of bacteria makes it unnecessary to depend on chlorine where tastes and odors are feared. **Powdered Fuel and Boiler Room Economy.** L. V. REESE, 150. **Water Pumps and Power Machinery.** D. H. HUNTER, 155. **Mechanical Equipment in Water Works Plants.** W. T. ALLIGER, 159. Specifications for the purchase of centrifugal pumps, electric motors, steam turbines, reduction gears and condensers. **Power Units and Mechanical**

Equipment. E. J. FERMIER, 165. **Specifications and Analysis of Gravel and Filter Sand—Where Sand May Be Obtained.** LEWIS O. BERNHAGEN, 169. **Modern Practice in Designing Aeration Units for Water and Sewage.** H. L. THACKWELL, 173. **Value of Preliminary Sedimentation in Water Purification.** FRANK BACHMANN, 173. Advantages of preliminary sedimentation in treatment of turbid waters are: removal of bulk of turbidity, reducing load on coagulation basins and consequent cost of clearing these basins; gives a water low in turbidity resulting in smoother plant operation; reduces cost of chemicals for coagulation and softening; reduces cost of water wasted with sludge as this water has not been treated with chemicals. Graphs show saving in chemicals which may be obtained by pre-sedimentation. **The Development of the Hyraulic Jump Mixing Flume for Water Purification.** J. W. ELLMS, 180. **Recent Developments in Water Purification.** GEORGE W. FULLER, 182. Superchlorination, dechlorination, split chlorination, prechlorination, double cogulation, double filtration, water softening, aeration, mechanically-cleaned settling basins, new coagulation method, boiler feed water, new purification works and experimental studies at Cincinnati on filter loading are all briefly discussed. **The Trend of Modern Methods in Water Purification.** C. ARTHUR BROWN, 186. Trend appears to be toward more ornate and pleasing type of architecture for plant, improved surroundings, more and better equipment, more stringent standards of purity for water. Changes in processes have developed from plant where only turbidity and bacteria were removed to modern plant removing in addition to color, iron and hardness and possibly adding iodine for goitre prevention, and adding or removing carbonic acid when necessary. Sedimentation, chemical treatment, measurement and control of flows, filtration, softening recarbonating, decarbonating, double treatment and sterilization development are outlined. **Relative Economy in Metering Services in Small Towns.** CHAS. ADE, 200. **The Design of Filter Plants with Low Costs of Construction and Operation.** JAS. H. FUERTES, 205. **Description of plants constructed at Harrisburg and Steelton, Pa., Dallas, Tex., and Denver, Colorado.** Discussion by FREDERICK W. WEED, 211. **Measurement of the Quality of Water.** JACK J. HINMAN, JR., 213. The safety of a water is today considered first, its attractiveness second and its mineral content third when quality of a particular supply is investigated. Changing ideas as to quality, from ancient times to present day are reviewed. **Saving and Keeping Elevated Water Storage Tanks or Towers and Standpipes in Sanitary Condition.** D. W. PYLE, 219.—*A. W. Blohm.*

Proceedings Lake Michigan Sanitation Congress, Third Annual Meeting Racine, Wis. September 24–25, 1926. The Congress included representatives of 51 municipalities from the states of Wisconsin, Illinois, Indiana and Michigan, besides seven boards of commissions and several industrial commissions. **Annual Report of President.** HENRY W. LEE, 5. **"The Case for Racine."** W. W. BAUER, M.D., 12. Review of typhoid fever, diarrhea, enteritis and quality of water supply of Racine. Filtration plant nearly completed consists of 2,600,000 gallon sedimentation basin, six 1,500,000 gallon filter units with plans for two more and a clear well with 3,000,000 gallons storage capacity. **The Izaak Walton League of America.** CHARLES W. FOLDS, 17. **Chicago**

Regional Planning Association. W. W. DeBerard, 18. **Stream Pollution in Michigan.** Edward D. Rich, 20. **A Visit to The Milwaukee Sewage Disposal Plant by the Lake Michigan Sanitation Congress.** T. Chalkley Hatton, 23. **Summary of Report on an Investigation of the Pollution of Lake Michigan in the Vicinity of South Chicago and the Calumet and Indiana Harbors—1924—U. S. Public Health Service.** Langdon Pearse, 31. Study undertaken comprised: sanitary survey of drainage area of Calumet River, utilizing available data from and supplementing same by additional field surveys; bacteriological studies of waters of Lake Michigan and public water supplies taken therefrom; collection and analysis of available data relative to influence of existing pollution of these water supplies upon public health; detailed study of precipitation and wind movement; as well as lake elevations in Calumet region. Survey of 123 industrial plants showed 14 plants to be discharging waste of sanitary significance. Survey of sanitary sewage indicates that along the water frontage of Hammond, Whiting, East Chicago and Chicago some 21,000 people discharge sewage directly into the lake. In Calumet River in Illinois some 30,000 people discharge. In Little Calumet River in Illinois and Indiana some 46,400 discharge. In Indiana Harbor Ship Canal, 1,500 discharge. Direction of flow in Grand Calumet River and Indiana Harbor Ship Canal is such that sewage from 93,900 persons flows at all times into the lake at Indiana Harbor. On watershed of Calumet River are 146,000 people whose sewage may possibly reach the lake if the Calumet River is completely reversed. Obvious remedy for present intolerable situation is abatement of existing pollution of lake.—*A. W. Blohm.*

Automatic Combustion Control. Leeds and Northrup Company, Bulletin 660, 1927. An automatic system of metered combustion control for boiler furnaces is described. An electrical current controlled by steam pressure and flow in the steam main cooperates with air or gas flow meters, furnace pressure meters, and stoker or fuel feeder meters to regulate stokers, fuel feeders, fans and dampers as required to preserve constant steam pressure, to secure the desired division of load among boilers, to insure the most favorable furnace percentage of excess air or CO_2, and to hold the most favorable furnace pressure. Each fire receives only its alloted air supply, regardless of whether it is thick or thin or whether one or several fires are fed from a common duct, or whether the furnace is near to or far from the chimney. The quantity of air supplied to burn each pound of fuel is definite. System permits manual intervention to any desired degree. Some of the boilers of a plant can, at will, be operated under hand control, with fuel and air automatically held in a fixed ratio, while the remaining boilers under full automatic control take care of the fluctuations in steam demand; or individual boilers can be operated by push button control or by actual manual adjustment of dampers, etc., as when bringing a cold boiler up to load. Apparatus and hook-ups are shown for both stoker and powdered fuel plants, also steam flow and pressure charts and CO_2 records illustrating the results attained in commercial plants under automatic control.—*A. W. Blohm.*

Celloboise as an Aid in the Differentiation of Members of the Colon-Aërogenes Group of Bacteria. H. N. JONES and L. E. WISE. J. Bact., **11**: 359–66, 1926. In a medium containing 0.5 per cent celloboise, 0.3 per cent beef extract, and 1 per cent peptone B. aërogenes produces acid and gas while B. coli does not.—*Edward S. Hopkins (from Chemical Abst.).*

Further Observations on the Utilization of the Salts of Organic Acids by the Colon-Aërogenes Group. S. A. KOSER. J. Bact., **11**: 409–16, 1926. The utilization of several organic acids of the dicarboxylic and tricarboxylic series by B. coli., B. aërogenes and related types were studied. Although the acids were structurally similar to citric, none afforded the same distinction between intestinal B. coli and other members of this group. B. coli was unable to use any of these acids with the possible exception of glutaric.—*Edward S. Hopkins (from Chem. Abst.).*

The Concentration of Sea Water as Affecting its Bacterial Population. C. B. LIPMAN. J. Bact., **12**: 311–3, 1926. One to one dilutions of sea water seems to result in a depressing effect on the growth of B. calcis on plates. Further dilution is completely destructive to the organism.—*Edward S. Hopkins (from Chem. Abst.).*

Note on the Occurrence of Bacteria in Oil Well Brine Samples. S. L. NEAVE and A. M. BUSWELL. J. Bact., **12**: 133–4, 1926. Thirty per cent of ninety-four samples showed denitrification. Further work may show that bacteria play a part in the chemistry of oil deposits.—*Edward S. Hopkins (from Chem. Abst.).*

The Destruction of Acetylmethylcarbinol by Members of the Colon-Aërogenes Group. F. S. PAINE. J. Bact., **13**: 269–74, 1927. It seems probable that the transient Voges-Proskauer reaction is due in most cases to destruction of the acetylmethylcarbinol by the organism. Some strains of B. coli and B. aërogenes can do this. A false negative in an old culture of B. aërogenes is probably not due to the exhaustion of peptone.—*Edward S. Hopkins (from Chem. Abst.).*

Viability of Bacterium Typhosum in Ice Cream. M. J. PRUCHA and J. M. BRANNON. J. Bact., **11**: 27–9, January 1926. Although this work considers the presence of B. typhosum in ice cream, yet it is of interest since it shows that the initial count of 51,000,000 colonies per cubic centimeter had decreased in five days to 10,000,000, in twenty days to 2,000,000, in a year to only 51,000; but even after two and one half years living organisms were still present. The material was kept at an average temperature of −4°F. during the experiment.—*Edward S. Hopkins.*

A Method of Staining Bacterial Flagella. P. H. H. GRAY. J. Bact., **12**: 273–4, October, 1926. A modification of Muir's method is given which is shown to be quite successful.—*Edward S. Hopkins.*

A Light Switch for the Microscope. C. S. MUDGE. J. Bact., **13:** 223–4, March 1927. Description of a handy switch to provide dual illumination for a microscope is given.—*Edward S. Hopkins.*

Gentian Violet Lactose Peptone Bile for the Detection of B. coli in Milk. MILDRED A. KESSLER and JOSEPH C. SWENARTON. J. Bact., **14:** 47–53, July 1927. A new medium is suggested for the detection of B. coli in milk. It is a modification of the brilliant green bile medium suggested by Muir and Harris, using gentian violet in the place of the former dye and a weaker strength of bile (1 per cent). One thousand and ten (1010) examinations for B. coli were made and all except ten showed growth typical for members of the group. [This methods is applicable to isolation of B. coli from water and is believed to be superior to plain lactose as evidenced by collaborative work in the abstractor's laboratory]—*Edward S. Hopkins.*

The Rate of Solution and Availability of Commercial Limes. R. T. HASLAM, F. W. ADAMS and R. H. KEAN. Ind. Eng. Chem., **18:** 19–23, 1926. The rate of solution (which in general determines the availability of lime) is shown to depend on the fineness and is directly proportional to the area and solubility of the lime. In acid forming a soluble lime salt, the increase in rate of solubility over that in water is proportional to the concentration of the acid. If an insoluble salt is formed, the rate of solution is decreased. For an availability test to be of value, it should be based upon the particular process in which the lime is to be used. Graphs are given.—*Edward S. Hopkins (from Chem. Abst.).*

Corrosion of Steels in the Atmosphere. W. G. WHITMAN and E. L. CHAPPELL. Ind. Eng. Chem., **18:** 533–5, 1926. The relative rates of corrosion of steel samples in the American Society for Testing Materials' long time atmosphere exposure test and in a rapid water spray tester are shown to be the same. The rate of atmospheric corrosion is related to the time the metal is wet and to the impurities in the atmosphere.—*Edward S. Hopkins (from Chem. Abst.).*

Effect of Oxygen Concentration on the Corrosion of Copper by Non-Oxidizing Acids. R. P. RUSSELL and A. WHITE. Ind. Eng. Chem., **19:** 116–8, 1927. Experiments were made to study the effect of dissolved oxygen on the corrosion of copper in dilute sulfuric, acetic, and hydrochloric acids. The corrosion was directly proportional to the concentration of dissolved oxygen. Graphs, tables, and photomicrographs are given.—*Edward S. Hopkins (from Chem. Abst.).*

Volumetric Determination of Alumina in Aluminium Salts. F. G. GERMUTH. Ind. Eng. Chem., **19:** 144–5, 1927. The method depends upon precipitating aluminium hydroxide with ammonia using methyl red as indicator, heating to boiling, filtering, dissolving the precipitate in a known volume of standard acid, and titrating the excess with standard alkali using methyl orange as indicator.—*Edward S. Hopkins (from Chem. Abst.).*

Controllable Variables in the Quantitative Study of the Submerged Corrosion of Metals. O. B. J. FRASER, D. E. ACKERMAN and J. W. SANDS. Ind. Eng. Chem., **19**: 332–8, 1927. The effects of oxygen, concentration, temperature, velocity, and concentration of active ions in submerged corrosion in acid are studied. Data are given for the corrosion of Monel metal and testing apparatus is discussed.—*Edward S. Hopkins (from Chem. Abst.).*

Recent Developments in Zeolite Softening. A. S. BEHRMAN. Ind. Eng. Chem., **19**: 445–7, 1927. An outline is given of zeolite softening up to the present time. The present synthetic "gel" zeolites are made by mixing sodium silicate and aluminum sulfate, or sodium aluminate and sodium silicate, of the proper concentration, drying and crushing. By means of this zeolite a much higher rate of exchange is obtained and economy is effected in operation and maintenance.—*Edward S. Hopkins (from Chem. Abst.).*

The Influence of Rust Film Thickness on the Rate of Corrosion of Steels. E. L. CHAPPELL. Ind. Eng. Chem., **19**: 464–7, 1927. The chemical characteristics of the surfaces of different steels determine their corrosive rates in the absence of rust films. In submerged corrosion, decreases in corrosion rates are shown to be proportional to the thickness of the rust film formed.—*Edward S. Hopkins (from Chem. Abst.).*

Some Variables Affecting the Behaviour of Limes Used in Causticizing. J. V. N. DORR and A. W. BULL. Ind. Eng. Chem., **19**: 558–61, 1927. The nature of the final precipitate can be greatly modified and its settling rate changed at least fifty fold, by changing the method of slaking and causticizing. Relative particle size may persist through the course of a chemical reaction between a solid and a solution.—*Edward S. Hopkins (from Chem. Abst.),*

The Intercrystalline Corrosion of Metals. H. S. RAWDON. Ind. Eng. Chem., **19**: 613–9, 1927. Numerous examples of the intercrystalline corrosion of several metals are cited. The effect of stress, both internal and external, and impurities in the metal are given. The importance of this type of corrosion in the cracking of metals is stressed. Preventive measures include annealing, protective coatings, and elimination of corrosive conditions.—*Edward S. Hopkins (from Chem. Abst.).*

The Embrittlement of Boiler Plate. S. W. PARR and F. G. STRAUB. Ind. Eng. Chem., **19**: 620–2, 1927.; cf. C. A. **20**: 2814. Embrittlement of boiler plate is caused by the action of sodium hydroxide on the metal under stress. A concentration of 6000 grains per gallon is necessary to produce cracking. Sodium sulfate will prevent embrittlement. Recommended ratios of sulfate to hydroxide are given.—*Edward S. Hopkins (from Chem. Abst.).*

The Mineral Waters of Courmajeur. GIOVANNI ISSOGLIO. Ann. accad. agr. Torino, **67**: 3–17, 1924. From Chem. Absts., **20**: 2132, July 10, 1926. Physical constants of radioactivity and chemical composition of waters of "La Saxe" (sulfuretted), "Vittoria" (carminative), and "Regina" (chalybeate) springs are given.—*R. E. Thompson.*

Report on Waters, Brine and Salt. (Determination of Hydrogen Sulfide in Water.) C. H. BADGER. J. Assoc. Official Agr. Chem., **9**: 125–7, 1926. From Chem. Abst., **20**: 2216, July 10, 1926. Collaborative comparison of old official method and method proposed by B. (C. A. **19**: 2383) showed latter to possess following advantages: greater rapidity, easier calculations, more concordant results, greater accuracy because larger samples can be taken, especially with relatively high hydrogen sulfide contents. Neutralization of acid samples is unnecessary. Alkaline samples must be neutralized, otherwise abnormally high results are obtained.—*R. E. Thompson.*

The Determination of Ammonia in Ammoniacal and Industrial Waters. CHARLES JUNGBLUT. Bull. soc. chim., **39**: 336–7, 1926. From Chem. Absts., **20**: 2216, July 10, 1926. Twenty cubic centimeters of the water is placed in 100-cc. flask, 10 cc. 5 per cent sodium hydroxide and 15 cubic centimeters 20 per cent barium chloride added, and mixture diluted to 100 cc. and filtered. Twenty cubic centimeters of filtrate, corresponding to 4 cc. of original water, is neutralized with hydrochloric acid with methyl orange as indicator and 5 cc. of 40 per cent formaldehyde added. The ammonia is transformed into hexamethylenetetramine and corresponding free acid is titrated with 0.1 N. sodium hydroxide with phenolphthalein as indicator. Method checks to within about 2 per cent with distillation method.—*R. E. Thompson.*

Filter for Water. D. HALL, J. H. KAY and HALL, & KAY, LTD. Brit. 240, 211, June 19, 1924. From Chem. Absts., **20**: 2218. July 10, 1926.—*R. E. Thompson.*

The Control of Alum Dosage in Water Purification. F. EGGER. Chem.-Ztg., **50**: 167, 1926. From Chem. Abst., **20**: 2216. July 10, 1926. Determination of decrease in carbonate hardness, pH, and reduction in turbidity are the best methods of controlling addition of alum to water.—*R. E. Thompson.*

Annual Reports of the Division of Water, Division of Sewage Disposal and Bureau of Water Works Extension, 1925. C. B. HOOVER, C. P. HOOVER and C. D. MCGUIRE. Supplement to The City Bull. (Columbus, Ohio), 16–47. From Chem. Abst., **20**: 2216, July 10, 1926. Hardness is reduced to 92 p.p.m. by split treatment, a reduction greater than could be effected with same quantities of lime and soda ash by ordinary method. Expense prohibits hot process, and disagreeable tastes prohibit over-treatment method.—*R. E. Thompson.*

The Chlorine Sterilization of Drinking Water. R. SCHWARZBACH. Gas u. Wasserfach **69**: 272–5, 1926. From Chem. Abst., **20**: 2217, July 10, 1926. Much greater efficiency of chlorine as compared to calcium hypochlorite, especially during high water seasons, shown by numerous tabulated tests.—*R. E. Thompson.*

Engineering Aspects of Treating Textile Water Supplies. H. L. TIGER. Mech. Eng., **48**: 435, 1926. From Chem. Abst., **20**: 2217, July 10, 1926. Gen-

eral description given of chemical feed apparatus, settling tanks, filters, and water softeners for treatment of water for textile industry. Removal of hardness by zeolite softeners is recommended as sodium salts do not react with soap or dyestuffs. Excess soda ash and lime, necessary for complete removal of hardness by lime-soda process, is highly undesirable in this industry. Care must be taken to prevent contamination by algae, iron, or organic matter after treatment.—*R. E. Thompson.*

Apparatus for Softening Water with Zeolites, etc. K. A. SPEARING and J. KERR-BOCK. Brit. 240, 598, August 9, 1924. From Chem. Abst., **20:** 2218, July 10, 1926.—*R. E. Thompson.*

The Determination of Dissolved Oxygen in Effluents. E. R. TROTMAN. Chem. Ind., **45:** 110T, 1926. From Chem. Abst., **20:** 2217, July 10, 1926. To rubber-stoppered bottle of about 260 cc. capacity, fitted with funnel and side tube with stopcocks, add 10 cc. petroleum and water to fill up almost to mark. Add water to complete required volume, and add reagents through funnel, which should extend to bottom of bottle.—*R. E. Thompson.*

Transportation of Liquefied Chlorine Gas. H. P. WELLS, H. M. MABEY and J. M. ROWLAND. Trans. Am. Electrochem. Soc., **49:** (preprint) 1926. From Chem. Abst., **20:** 2230, July 10, 1926. Regulations of Interstate Commerce Commission re-shipping of liquid chlorine reviewed. Specifications cited for testing the steel containers, construction of valves, filling and emptying cylinders, and precautions in transportation. New tank cars, and methods of filling and emptying, are also described.—*R. E. Thompson.*

Fused Cement and Sands Containing Humic Acids. A. F. ROSCHER. Teknisk Ukeblad; Rev. mat. constr. trav. pub., **197:** 33–5, 1926. From Chem. Abst., **20:** 2236, July 10, 1926. Compression tests were made to determine relative strengths of portland and fused cements when mixed with sands containing humic acids. Content of humic acid was determined colorimetrically by comparison of an ammoniacal extract of the samd with a standard solution. Results indicated that presence of humic acid reduces strength of portland cement to much greater extent than that of fused cement. With former, effect is due to chemical reactions, while with latter effect is due to physical and mechanical factors.—*R. E. Thompson.*

The Radium Content of the Hot Springs of Gastein and Karlsbad. HEINRICH MACHE and FELIX KRAUS. Physik. Z., **27:** 205–6, 1926. From Chem. Abst., **20:** 2278, July 20, 1926. Radium content of springs at Gastein varies from 0.2 to 154, expressed in billionths of grams per litter, and of those of Karlsbad from 34.7 to 53.9.—*R. E. Thompson.*

Action of Natural Alkali Waters on Portland Cement. G. W. BURKE. Proc. Iowa Acad. Sci., **31:** 277, 1924. From Chem. Abst., **20:** 2236. July 10, 1926. Magnesium salts are most active on cement. Magnesium sulfate in intimate contact with cement reacts very rapidly with all calcium in latter, producing

calcium sulfate and an insoluble compound of magnesium. The reaction results in material increase in weight and volume of cement. Magnesium chloride rapidly reacts with cement, replacing practically all the calcium by magnesium. Chemically equivalent amounts of calcium and magnesium are involved in the exchange. Slight decreases in weight and volume of cement accompany this reaction. Salts of sodium are less active than corresponding salts of magnesium.—*R. E. Thompson.*

Some Properties of Lumnite Cement. L. J. ROTHGERY. Mich. Eng. Expt. Sta., Bull. **4**: 1926. From Chem. Abst., **20**: 2236, July 10, 1926. Lumnite cement concrete subjected to freezing immediately after mixing failed to stand a satisfactory test. Same concrete when allowed time for hydration after thawing attained strength slightly below that of samples cured under normal conditions. Concrete subjected to freezing after final set had occurred attained usual 24-hour strength. In general, ultimate strength of Lumnite cement concrete is not affected by freezing. Suggestions are made for protection of concrete during freezing weather. Study was also made of bond between portland cement and Lumnite cement under varying conditions.—*R. E. Thompson.*

California Quick Hardening Concrete. C. L. MCKESSON. California Highways, **2**: 11, 6–8, 1925; Rock Products, **29**: 5, 46–7, 1926. From Chem. Abst., **20**: 2237, July 10, 1926. Tests of high early strength concrete using 6 sacks portland cement, 7 sacks portland cement plus 2 per cent calcium chloride, and 6 sacks Lumnite cement per cubic yard of concrete gave compressive strengths at 24 hours of 951, 2020, 5360; at 48 hours, 1722, 2860, 5862; and at 28 days, 4338, 4751, 5796 pounds per square inch. Costs of cement (and calcium chloride) per square yard of 6-inch pavement were $0.70, 0.86 and 2.12.—*R. E. Thompson.*

Substances in Rain and Snow. NICHOLAS KNIGHT. Proc. Iowa Acad. Sci., **31**: 325–6, 1924; cf. C. A., **16**: 3993; **17**: 1854; **18**: 2776. From Chem. Abst., **20**: 2379, July 20, 1926. Twelve samples of snow and 29 of rain were collected and analyzed during period October 1, 1922—June 1, 1923. Chlorides varied from 3.54 to 28.1 p.p.m. Total nitrogen averaged 0.896 p.p.m., and was constant; free ammonia 0.34; albuminoid ammonia 0.264; nitrogen in nitrates 0.346 and in nitrites 0.397; sulfates (SO_3) 0.147.—*R. E. Thompson.*

Composition of Lake Epecuén Water and Its Applications. H. CORTI. Añales asoc. quim. Argentina, **23**: 509–26, 1925. From Chem. Abst., **20**: 2379, July 20, 1926. Tables of analyses.—*R. E. Thompson.*

The Preparation of Zeolitic Water-Softening Materials. E. L. BARTHEL. Proc. Iowa Acad. Sci., **31**: 275–6, 1924. From Chem. Abst., **20**: 2380, July 20, 1926. Raw untreated greensand is very colloidal and has little or no water-softening power. By heating it to 400° and subsequently treating it with sodium chloride solution, stable zeolitic sand is obtained which has good water-softening power. This method is in use at present time. Modification of this

treatment gives zeolite with greater water-softening power. Sand is first treated with concentrated calcium chloride solution and subsequently with concentrated sodium chloride solution, then rapidly heated to about 800° and quenched in salt solution.—*R. E. Thompson.*

Water-Softening Reagents. A. S. Behrman and W. H. Green. Can. 258,822, March 9, 1926. From Chem. Abst., **20**: 2381, July 20, 1926. Base-exchange material is prepared by treating natural greensand with solution of caustic alkali and drying product to remove excess moisture.—*R. E. Thompson.*

Apparatus for Softening Water, etc. I. B. Tanner. U. S. 1,587,129, June 1. From Chem. Abst., **20**: 2381, July 20, 1926.—*R. E. Thompson.*

Water-Softening Reagent. A. S. Behrman. Can. 258,823, March 9, 1926. From Chem. Abst., **20**: 2381, July 20, 1926. Base-exchange material is prepared by soaking greensand in alkali salt solution and then in alkali silicate solution.—*R. E. Thompson.*

Base-Exchange Silicate. H. J. Wheaton. U. S. 1,586,764, June 1. From Chem. Abst., **20**: 2381, July 20, 1926. Double base-exchange silicate is prepared in which practically all soluble substances formed by reaction of constituent solutions are retained in the gel.—*R. E. Thompson.*

Detection and Determination of Free Chlorine in Drinking Water. I. M. Kolthoff. Chem. Weekblad, **23**: 203–4, 1926. From Chem. Abst., **20**: 2380, July 20, 1926. Add to 100 cc. water few drops of acetic acid, 1–2 cc. 2 N sodium acetate, and 10 drops 0.1 per cent dimethyl-*p*-phenylenediamine. Compare with iodine solution of known strength. Sensitiveness is 0.03 p.p.m. Reagent gives red color with all weak oxidizing agents, and is decolorized by excess. Ten parts per million iron can be detected in acetic acid-sodium acetate solution, while addition of sodium bicarbonate reduces sensitiveness considerably. Tetramethyl-*p*-phenylenediamine gives violet color.—*R. E. Thompson.*

Recommended Process for Bronze-Welding Cast Iron Pipe Not Exceeding 12-Inch Diameter. Linde Air Products Co. Proc. Am. Gas Assoc., 1925, 981–8. From Chem. Abst., **20**: 2306, July 20, 1926. Details given covering all phases of work, including training and examination of welders, organization of crews for laying welded pipe, specifications for pipe, welding rod and flux, and method of welding proper.—*R. E. Thompson.*

Geology and Water Supply in the Vicinity of Danzig. H. Stremme. Gas- u. Wasserfach, **69**: 437–42, 1926. From Chem. Abst., **20**: 2474, August 10, 1926.—*R. E. Thompson.*

Hydrogen-Ion Concentrations of Waters of Norwegian Mountains, and Their Bearings Upon the Classification of Freshwater Localities. K. Münster Strom. Nyt Mag. Naturvidensk. (Oslo), **62**: 237–44, 1925; Botan. Abst.,

14: 1286. From Chem. Abst., **20:** 2349, July 20, 1926. H-ion concentrations of 71 bodies of water were determined. Aëration and stagnation play most important part in determining the pH. Mean value was 7.6 in 10 typically aërated bodies and 4.5 in 35 typically stagnant bodies. In peaty bogs, carbon dioxide assimilation by algae never sufficed to raise pH to appreciable extent, but when such water was aerated in brooklets, etc., reaction soon approached normal. Specific reaction of water is potential factor in determining character of biota in general, and especially the algal flora; but it must be considered in conjunction with other physical and chemical properties of the water.—*R. E. Thompson.*

The Elimination of Phenol-Bearing Wastes in the Gas Industry. R. L. BROWN. Am. Gas. Assoc. Monthly, **8:** 211–4, 240, 254, 279–82, 1926. From Chem. Abst., **20:** 2405, July 20, 1926. Coke quenching with phenol-containing ammonia still waste leads to corrosion difficulties due to vapors evolved. Waste can be handled in activated sludge plant provided its volume is not more than 5 to 10 per cent of total volume of sewage. Most practical methods appear to be "bacterial filter" consisting of lignite or similar material revivified by bacterial action, and benzene extraction system in which phenols are recovered from weak ammonia liquor before entering still. Experimental and plant data are given relating to latter processes.—*R. E. Thompson.*

The Washington Suburban Sanitary District. ROBERT B. MORSE. Proc. Am. Soc. Munic. Improvements, pages 181–91, 1926–7. The Maryland suburbs of Washington comprise a number of small towns lying in two counties. The water systems in general were too small and delivered water inadequate in amount and poor in quality. The sewerage systems were also inadequate in many instances. The legislative act establishing the Washington Suburban Sanitary District was passed in 1918. The district has an area of 96 square miles and a population of about 50,000. A commission of 3 members administers the affairs of the district. The commission has the powers usually accorded to municipal officials with respect to construction and operation of water and sewerage systems. Its bond issues must be approved by the Public Service Commission, and its charges and rates are subject to review by that body. District bonds for construction work may be issued, without referendum, up to 12 per cent of the assessed value. All of the municipal and private water and sewerage systems have been acquired by purchase. The purchased systems comprised about 53 miles of water mains and 60 miles of sewers. The water system now contains about 200 miles of mains and the sewerage system about 150 miles of sewers. There are about 8,500 water connections and 7,200 sewer connections. Outstanding bonds amount to nearly $6,000,000. Three water filtration plants with a total capacity of 5 million gallons daily barely supply the requirements during periods of excessive demand. The fixed charges on bonds are met through a small addition to the tax rate over the whole district and a front-foot benefit charge on property abutting on water and sewer lines. The water rates cover the maintenance and operating expense on both water and sewerage systems. The charge on the tax rate represents theoretically the fixed charges on part of

the construction cost of purification and pumping works, trunk lines, etc. Most of the cost of construction is borne through front-foot benefit charges on property abutting on water mains and sewers. All construction work except the installation of house connections is accomplished by long-term sinking-fund bonds. The benefit charge is spread over the life of the bonds, payable in the form of a small annual sum. This feature has done more than any thing else to permit the construction of water and sewer systems in a sparsely settled suburban area. The property owner has the privilege of paying off the benefit charge at any time. The rates include a fixed ready to serve charge of from $4.00 for a $\frac{5}{8}$-inch meter to $360.00 for an 8-inch fire line meter, and a consumption charge varying from 18 cents per thousand gallons for the first 50,000 gallons used semi-annually to 9 cents per thousand gallons for all water consumed above 2,500,000 gallons monthly. Public fire hydrant service and water for municipal uses are furnished free. The coagulation of the water at the filtration plants is under pH control all the time and the filter effluents are constantly observed through turbidity detectors attached to the effluent piping.—*John R. Baylis.*

The Need of Metropolitan Utility Districts. V. B. Siems and D. B. Biser. Proc. Am. Soc. Munic. Improvements, pages 236–46, 1926–7. It may be assumed that isolated plants will give way to single giant developments more capable of providing the utility at a lower cost. Improvements in transportation makes the dispersal of the urban population into the country greater than heretofore. To construct and operate utilities to serve sparsely settled territory requires enormous capital investment. The lack of foresight in reserving water supply for the future is a danger to growth, for it is the predominant safeguard of health, protection against fire danger, business and industrial interruptions, and disruption of home comforts. Curtailment of water supply sources by the grant of water power rights sometimes requires the development of further removed sources. The Federal Water Power Act passed in 1920 failed to make provision for safeguarding the interest of the cities and towns which may be forced to go to navigable streams or their tributaries for water supplies. The authors urge that action be taken to save the rights of the public. The State of Nebraska has enacted laws governing metropolitan utility districts, which provide that whenever a metropolitan city and one or more adjacent municipalities or precincts are served in whole or in part by one water works owned and controlled by the metropolitan city, the territory included constitutes a metropolitan district. The authors recommend that adequate legislation be secured to establish utility districts. —*John R. Baylis.*

Microscopic Life in Texas Waters. John B. Hawley. Proc. Am. Soc. Munic. Improvements, pages 247–77, 1926–7. The author gives the history, morphology, and phagology of microscopical organisms occurring abundantly in many water supplies of Texas. There is a good explanation of the occurrence, viability, length of life, and seasonal distribution of such organisms. The tables by Kellerman showing the susceptibility of a number of microorganisms and fish to copper sulfate are given. Twenty-nine plates from

drawings and 9 from microphotographs illustrate a number of organisms commonly found in Texas waters.—*John R. Baylis.*

NEW BOOKS

Standards Yearbook—1927. National Bureau of Standards, Department of Commerce. The first issue of the Standards Yearbook "represents an effort to present an adequate picture of the diversification and ramification of the standardization movement which has spread throughout the world with astonishing vitality during the 25 years that have elapsed since the establishment of the National Bureau of Standards. It contains outlines of the activities and accomplishments of not only this bureau and other agencies of the Federal Government and the States and municipalities, but also of the American societies and associations of which standardization is a major or very important activity. Descriptions and illustrations are presented of all the fundamental national standards of the United States. Moreover, outlines are given of the various foreign, national, and the several international standardizing agencies."—*A. W. Blohm.*